MANAGING WICKED ENVIRONMENTAL PROBLEMS

REPORT TO
JACK BLACKWELL, REGIONAL FORESTER
USDA FOREST SERVICE, PACIFIC SOUTHWEST REGION

MARCH 30, 2004

BY

RONALD E. STEWART
LAWRENCE C. WALTERS
PETER J. BALINT
ANAND DESAI

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Ronald E. Stewart
Lawrence C. Walters
Peter J. Balint*
Anand Desai

With research assistance from

Beena Chundevalel
Yija Jing
Nancy Kanbar
Melissa Milne
David E. Phillips

*Corresponding author: Peter Balint, pbalint@gmu.edu
Mailing address: 4400 University Drive, MSN 3F4, Fairfax, VA 22030
Web site: http://gunston.doit.gmu.edu/snfpa_risk/

ABOUT THE AUTHORS

Ronald E. Stewart, Ph.D., is Visiting Associate Professor and Graduate Coordinator in the Department of Environmental Science and Policy at George Mason University.

Lawrence C. Walters, Ph.D., is Associate Professor and Director of the MPA Program in the Department of Public and International Affairs at George Mason University.

Peter J. Balint, Ph.D., is Assistant Professor with a joint appointment in the Department of Public and International Affairs and the Department of Environmental Science and Policy at George Mason University.

Anand Desai, Ph.D., is Associate Professor in the School of Public Policy and Management at The Ohio State University.

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CHAPTER 1. MANAGING WICKED ENVIRONMENTAL PROBLEMS: AN OVERVIEW

INTRODUCTION

This document is the second of two reports completed by the Sierra Nevada Forest Plan Amendment (SNFPA) Risk and Uncertainty Panel. The Panel was constituted in January 2003 with the charge to inform the Regional Forester and other interested parties about the nature of decision making in a policy environment characterized by multiple and conflicting risks and uncertainties. In October 2003, the Panel submitted a summary report focusing on the SNFPA process, "Risk and Uncertainty in Management of the Sierra Nevada National Forests" which is available at the Panel's Web site: http://gunston.doit.gmu.edu/snfpa_risk/.

This second report examines in more detail the current thinking on addressing complex problems in conservation. In completing this task, this final report reviews relevant academic and professional literatures and discusses efforts to address such problems, with a particular concentration on adaptive management and public engagement. While we frequently return to the SNFPA case as an example to illustrate our points, this report is relevant for a range of complex public management dilemmas—environmental and otherwise.

After this brief review of our findings, we begin by examining how risk and uncertainty are defined and interpreted in the literatures of various disciplines, including economics, psychology, and anthropology. The next chapters report trends in thinking about complex problems, particularly in the environmental arena. Subsequent chapters discuss alternate responses to such problems, focusing on those that have been influential both in the SNFPA case and in environmental problems more generally. In particular, we address adaptive management, the precautionary principle, and participatory decision-making processes, in each case exploring (1) the concept's history, (2) its strengths and weaknesses as a decision-support tool, and (3) applications to forest management. Along the way, we offer general recommendations for strengthening adaptive management as a response to problems in conservation by integrating adaptive management and public priorities more completely.

NATURAL RESOURCE MANAGEMENT DECISION PROBLEMS

In characterizing the decision environment public agencies face in managing natural resources, we find three main drivers influencing ecosystems over time:

1. external human factors associated with both neighboring communities and the broader interested public, such as social, political and economic values and actions;

2. natural events and processes largely beyond the agency's control, including lightning strikes, droughts, plant community succession, and long-term climatic changes; and
3. agency management strategies and practices, including changes in administrative and budget priorities, rotation of key officials and commitment to public participation.

All three inputs affect ecological conditions in the field. These ecological effects are then translated into outcomes as, in the case of the Forest Service, wildfire acres burned, old-growth habitat gained or lost, changes in endangered species' populations, recreational facilities, and timber volume produced. In turn, these ecological effects and outcomes—both observed and projected—influence external stakeholder acceptance of and reaction to the agency and its management activities. Our research suggests external stakeholders are willing to accept short-term sacrifices if there is a reasonable likelihood such actions will result in greater long-term gains. However, stakeholders will and do evaluate agency management decisions on factors other than ecological outcomes. Whether because of uncertainty, lack of trust, or some other reason, external stakeholders also scrutinize and evaluate the agency based on its management choices and the processes used to arrive at those choices.

In addition to holding varying preferences regarding processes and outcomes, stakeholders diverge in their understanding of—and aversion to or tolerance for—the range of risks and uncertainties associated with natural resource management. Stakeholders act on their preferences and levels of risk aversion or tolerance, and external stakeholders influence the agency's management strategies and practices through various mechanisms. These include participating in public meetings and other opportunities for public comment, bringing political influence to bear, and initiating formal appeals and legal challenges.

The public agency charged with management of a complex ecosystem is thus required to

1. adequately and effectively integrate public social, political and economic values into its planning, modeling, decision-making, and post-decision evaluation and monitoring;
2. work within natural constraints and uncertainties while addressing perceived risks; and
3. constantly adapt its own management strategies and procedures based on new scientific understanding and changes in public priorities.

Risk and Uncertainty in Environmental Management Dilemmas

One of the Panel's tasks is assessing the literature on risk and uncertainty and its relevance to managing natural resources. We begin with a brief glimpse into the vast literature on uncertainty and risk, concepts which have been viewed by different academic disciplines through a variety of lenses.

The dilemma faced by decision makers, and public agencies in general, is how to

- perceive and characterize different sources of scientific, administrative, and stochastic uncertainty;
- incorporate them in some assessment of the risks they face;
- communicate these risk perceptions to the community; and
- begin addressing them through administrative action.

Uncertainty has been correctly attributed, in many contexts, to lack of information. Some of this uncertainty can be reduced through better understanding the sources of uncertainty and gathering additional information about them. In the main, uncertainty is a neutral concept, a property of phenomena or events and the relationships among them. Since many decisions are about actions that influence a future course of events, even fully comprehending the current contexts cannot eliminate the future's inherent unpredictability. Uncertainty must be acknowledged as an influential factor, and while it can potentially be reduced, it cannot be eliminated.

What we choose to consider a risk, on the other hand, is subjective. Determining risk entails assessing the consequences of decisions or the implications of the uncertainties being resolved. What consequences to consider, how to value them, and how to incorporate them in the decision calculus are subjective considerations to be assessed by the decision makers. Hence, risk identification is a subjective process that reflects the communities' and decision maker's values and norms.

Given risk's subjective nature, communicating how it is assessed and explaining how it has been incorporated in determining consequences of decisions made under uncertainty become important aspects of the decision maker's responsibility to both agency and external stakeholders. Herein lies the decision maker's dilemma:

1. First, the agency analysts must communicate the multiple uncertainties inherent in the decision problem without simplifying them so much as to misrepresent their nature and extent, but also not making the explanations so complex as to render them unintelligible to decision makers and the informed but lay public.
2. Second, in assessing risk, the question the decision maker has to address is: "Whose values should be considered?" Since the answer to this question in itself is a value judgment, there is no objective method for answering the question. Garnering support for a decision thus requires establishing public trust in the decision process and the decision makers. This trust, once eroded, is extremely difficult to restore.

Defining Wicked Problems

Clearly, some public management problems, including environmental problems, are more difficult to resolve than others. Renn (1995) suggests that environmental debates operate on three levels of complexity; therefore, conventional ecological risk assessment, designed to reduce uncertainty and make problems more manageable, has decreasing utility as an input into policy making as levels of complexity and conflict increase. For straightforward problems, he argues, scientific analysis can serve as a basis for policy

making with little controversy. At a medium level of complexity, public trust in the implementing institutions and their technical expertise is required. At the highest level of complexity and conflict, profound social and cultural values come into play, and stakeholder investment is essential. In these most complex cases, the processes of defining shared values, common goals, desirable outcomes, and acceptable risks become political. Such problems are difficult even to formulate. Consequently, technical analyses alone—which do not integrate social values and deliberation—cannot provide an adequate decision-support framework. Problems that do not lend themselves to easy formulation, much less easy solutions, are referred to in the literature as "wicked problems." We demonstrate that the SNFPA process is a wicked problem.

DECISION MAKING UNDER RISK AND UNCERTAINTY

Much of the decision-making literature focuses on the "rational" decision maker. In addition to the fact that this concept of a rational decision maker has come under criticism, when dealing with wicked problems one must consider not just individual rationality, but numerous other rationalities, e.g. political, administrative and legal. Multiple rationalities, environmental contingencies, and varied valuations of the inherent risks make obtaining satisfactory solutions to wicked problems extremely difficult.

Addressing Wicked Problems

Wicked problems have been variously described as being untamed or intractable. Researchers discuss approaches to addressing such problems, or talk of developing an appreciation for them, but rarely do participants succeed in reaching agreement on a unique formulation of the problem. Some conservative approaches to addressing wicked problems involve invoking a precautionary approach, one that tries to ensure that solutions do not make matters worse. While the precautionary principle has great intuitive appeal, its implementation can lead to imposing constraints that drastically reduce the degrees of freedom available for administrative action. In addition, we show that implementing the precautionary principle can result in the opposite of its intended effect, causing more harm than good. Particularly, in the presence of uncertainty, where it is difficult to ascertain which action will lead to what consequence, a precautionary approach does not provide useful, practical guidance.

An adaptive management strategy, by focusing on management experiments, avoids a precautionary approach's paralyzing effects without making a long-term commitment to a particular course of action. However, as such experiments may sometimes be long term, large scale, and/or costly, local experimentation is more practical. These experiments would yield useful information about the consequences of managerial actions, which can be modified as the additional information warrants. An essential component of adaptive management is monitoring these local experiments to determine how well their objectives were achieved. Adaptive management can be described as a pragmatic approach to "learning by doing" that entails cycles of implementation, experimentation, monitoring, feedback, and revised implementation. In academic and professional literature, the

concept of adaptive management is now being expanded to address social and political, as well as scientific, uncertainties.

However, adaptive management as it is currently understood does not necessarily imply seeking external stakeholder input regarding the experiments' nature and substance. In particular, the scientific uncertainty and disagreement over social values that characterize wicked problems make it difficult, if not impossible, for public managers to address these complex dilemmas successfully as long as adaptive management and public participation operate on separate tracks. Our literature review suggests that scientific adaptive management as currently practiced by the Forest Service and other agencies should be broadened to include collaborative, responsive, and inclusive participatory processes. In other words, adaptive management as currently applied is necessary but not sufficient to address wicked problems.

Participatory policy analysis engages all stakeholders in long-term processes of analysis and deliberation with the objectives of educating participants, informing decisions, and reaching consensus responses to complex policy dilemmas. Carefully designing the participatory process is essential for its success:

- The agency must be committed to public participation.
- Appropriate stakeholders must be identified and engaged.
- The objectives for participation must be clearly stated.
- Knowledge necessary for effective participation must be identified and disseminated.
- The sponsoring agency's organizational structure must be evaluated to determine its willingness to accept and act on knowledge gained through the participation effort.
- Procedural fairness must be assured.
- Active, two-way communication should take place throughout the process.
- Finally, the participation effort's effectiveness should be monitored and evaluated.

Currently there are problems associated with full public participation from both agency and external stakeholder perspectives. Agencies have the final responsibility for decisions and are constrained, by law, from sharing that responsibility with external stakeholders. From the external stakeholder perspective, it is difficult to remain engaged over the extended time periods it takes to make such decisions. Although attractive in principle, participatory policy analysis is difficult to implement successfully in practice, especially at the scale of many wicked conservation problems such as managing the Sierra Nevada National Forests.

LOOKING TO THE FUTURE

We conclude this report with our assessment of the different approaches to addressing problems such as those faced by the Forest Service in managing the Sierra Nevada National Forests. We note that the task of addressing wicked problems is broader than simply attempting to solve a problem: A major component of the resolution entails

educating the public about what it means to address such problems. In particular, stakeholders—including both external interests and agency decision makers—must recognize that wicked problems do not lend themselves to optimal solutions. Instead, the best achievements are temporary actions that move toward more desirable states of affairs. Case studies demonstrate that, as in the case of the Forest Service in the Sierra Nevada, even when public agencies implement state-of-the-art decision-making strategies, both the process and the outcomes frequently remain unsatisfactory to many stakeholders.

Although it is clear wicked problems are inherently difficult, administrators must make decisions and take action in spite of all the risks and uncertainties that generally accompany such problems. Thus, we propose a modified decision-making approach which blends current thinking on addressing wicked problems and stakeholder participation with our understanding of the best practices already implemented by the Forest Service and other agencies to address such problems. Our approach is a "learning network": an adaptive, iterative, deliberative, analytical participatory process for decision making in a wicked problem environment. An important component of this approach is incorporating stakeholder preferences into the ecological models that resource management agencies currently use to support decision making.

CHAPTER 2. DECISION MAKING UNDER RISK AND UNCERTAINTY

INTRODUCTION

In the past few years, there has been a major change in understanding ecosystems. Formerly, the dominant paradigm was of ecosystems which, when mature, were stable. They were closed, unaffected by external influences, regulated internally, and behaved deterministically. If this stable condition were to be disturbed, an ecosystem would progress through a series of successive stages back to its original, stable, homeostatic state (Daly 1993). Of course, it does not work this way.

The current paradigm is of much more open systems, in constant states of flux, affected by a series of stochastic factors originating both inside and outside the ecosystems. As a result, they are probabilistic and multi-causal rather than deterministic and homeostatic (Daly 1993). The current model also recognizes that human impacts almost always play an important, and often dominant, role in affecting a system's status (Smith 1997). Present knowledge also emphasizes that uncertainty is central to managing living resources. It follows, then, that ecosystems are characterized by uncertainty—in their basic ecology and biology, in their economic parameters, in the effect(s) of management actions, and there is even uncertainty as to whether or not it is possible to achieve management objectives. Therefore, the management must recognize uncertainty as an overriding factor.

Managing in the face of uncertainty has an added and essential requirement to identify and characterize risk. The presence of risk and uncertainty does not mean that a definite management decision cannot be made, but it emphasizes management's need to think in terms of probability and risk assessment. Management in the presence of uncertainty requires (1) defining objectives (including sustainability where appropriate) and their time scale(s), (2) identifying the managers' options, i.e., what decisions can be varied, then (3) analyzing available data to determine what is known and what is not.

When considering the future and/or the consequences of current managerial actions, it is essential to recognize the importance of distributions rather than single point estimates. That is, in the face of uncertainty, it is not possible to identify a single future, but instead a range or distribution of likely futures and a consequent range of effects of subsequent management efforts. Rigorous modeling is required to define the safety or precautionary approach: modeling to simulate the whole management system, applying sensitivity analysis to determine the stochastic elements in the system, and finally defining through the models the likely outcomes of various management options.

Before discussing managerial options, however, it should be recognized that ecosystem "uncertainty" and "risk" are nebulous concepts which must be defined and distinguished.

The treatment of these concepts varies across the social sciences. Decision making processes underlying managing the Sierra Nevada National Forests seem to draw upon the various conceptualizations found in the psychology, anthropology, sociology, geography, and economics literatures. We summarize the main themes from these disciplines to provide insights into the meanings associated with these different notions of risk and uncertainty as they are used in deliberations on managing forests.

UNCERTAINTY

General Categories of Uncertainty

Given the nature of science and its development, scientific "truths" are always subject to review and revision. Scientific certainty, to the extent it exists, is a probabilistic notion; hence, it is exceedingly rare for a large group of scientists to agree with certainty about anything, especially about something as complex as an environmental or ecosystem-level problem. When talking about living systems, great scientific uncertainty is the norm: in our complex, dynamic environment, knowledge has limits, and certainty is difficult to attain. Thus, uncertainty far outweighs knowledge of cause and effect.

Generally, uncertainties can be placed in the following categories (Tickner 1999):

- *Parameter uncertainty* refers to missing or ambiguous information about factors underlying uncertainties. This type of uncertainty can potentially be reduced by gathering more information or by using better collection and analysis techniques. However, if it is due to variability in these factors' nature, it may not be possible to reduce this type of uncertainty without obtaining a better understanding of the uncertainty's root causes. In attempting to determine the consequences of environmental releases, in particular, uncertainty regarding the full range of individual reactions could make it difficult to determine an individual's potential susceptibility to harm.
- *Model uncertainty* refers to gaps in scientific theory, or imprecision in the models used to bridge information gaps. As models are abstract, constructed to explain current or past events or to predict the future, they are only as good as the information used to build them (garbage in = garbage out). Comprehensive models of open and interdependent environmental systems are, by definition, incomplete—and therefore limited in their descriptive or predictive powers.
- *Systemic or epistemic uncertainty* refers to the unknown effects of cumulative, multiple, simultaneous and interactive exposures. Systemic uncertainty can be an important confounding factor in large-scale and/or long-term analyses.
- *Politically induced uncertainty* refers to deliberate ignorance on the part of agencies charged with protecting the environment. An agency may decide not to study a hazard, limit the scope of its analysis, and downplay uncertainty in its decisions.
- *Indeterminacy* means that the uncertainties involved are of such magnitude and variety that they may never be significantly reduced.

- *Ignorance* has two faces: positively, it is a humble admission that we do not know how much we do not know. Negatively, it is the practice of making decisions without considering uncertainties.

Case Study: Uncertainty in the Sierra Nevada

We begin with a discussion of how uncertainty manifests itself in managing the Sierra Nevada forests. In the Sierra Nevada case, as in any managerial context, we define "uncertainty" as a neutral analytical property of an event, relationship, phenomenon, or other important consideration that may be reduced through better science, but generally cannot be eliminated. In this context, uncertainty is the likelihood of the occurrence of an event, relationship, phenomenon, or other important consideration. This likelihood of occurrence may be unknown, or may have a distribution of possible values, but it is not under the immediate control of Forest Service decision makers.

In describing uncertainty as value-neutral, we highlight two important points:

1. Uncertainty is used to describe probabilistic events, whether or not it is possible to quantify those probabilities. For example, the distribution of naturally occurring fire events may be calculable, and therefore the probability of fire during a specific time interval may be estimable. The likelihood of important budget changes as a result of shifts in national public policy priorities during the next 50 years may not be estimable. In both cases, however, "uncertain" is the analytical term used to describe the events.
2. Uncertainty does not inherently involve a value position on the part of the analyst or decision maker. The probability of a lightning strike, for example, is independent of attitudes toward fire hazard, owl habitat, or any other value position. In this sense, uncertainty is a neutral concept.

There are three broad categories of uncertainty in the decision context facing the Forest Service: *scientific*, *administrative (or implementation)* and *stochastic*.

To say that something is *scientifically uncertain* within the context of the Sierra Nevada decision problem is to acknowledge that forests are complex systems and that our knowledge of them is incomplete. As a result, no one can state with certainty the long-term outcome(s) of any given management strategy, including maintaining the status quo. Key areas of scientific uncertainty include:

- old-growth forest and old-growth forest habitat acreages determined under the various alternatives as projected by vegetation models,
- the population of old-growth-dependent species associated with these projected acreages and the resulting viability probabilities as projected by the California Wildlife Habitat Relations Model and viability models, and
- annual or decadal acreages burned, and burn severity, as projected by such models as FLAMMAP, SPECTRUM, and FARSITE.

Scientific uncertainty is often expressed as a calculated or estimated confidence interval around a predicted value or outcome.

Administrative or implementation uncertainty refers to the vagaries of managing in a political environment in which public goals and priorities, societal needs and conditions, and organizational capacities change over time. Finally, *stochastic uncertainty* refers to those events that are largely random, unpredictable, and uncontrollable, such as lightning-caused ignitions or random changes in species populations.

Each of the factors identified in Figure 1 is associated with specific uncertainties. In addition, the stakeholders' assessment of outcomes also involves uncertainties, as stakeholder perceptions, values, and priorities may shift over time.

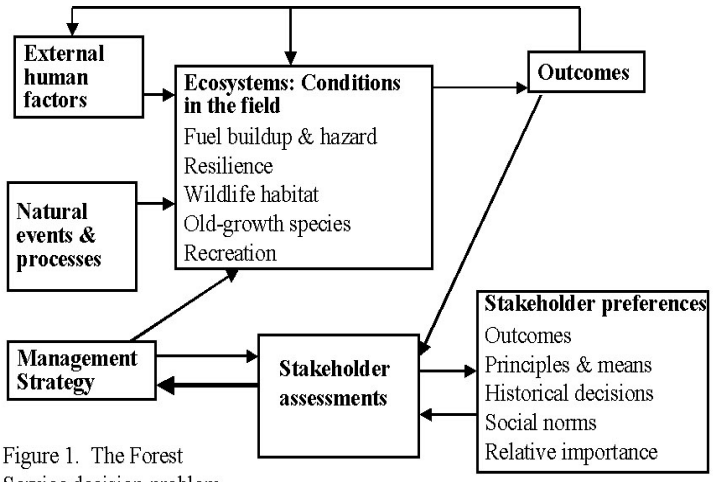


Figure 1. The Forest Service decision problem

Some examples of the multiple uncertainties in this decision are presented in Table 1.

Table 1. Uncertainties in the Sierra Nevada Forest Plan Management Decision-Making Process

	Scientific	Administrative or Implementation	Stochastic
Ecosystem	Representativeness of sample inventory.	Sampling and inventory implementation.	Measurement error in the initial inventory.
Natural Events and Processes	Climate change.	• Lack of access to affected areas. • Lack of understanding of the interaction between administrative action and naturally occurring stressors.	• Number, size, and location of ignition events. • Drought conditions and related disease- and insect-produced stresses.
External Human Factors	Incidence of invasive species.	Adjacent development in surrounding areas.	Changing societal needs and priorities.
Management Strategy	• Externalities (e.g., air quality, economic impacts). • Long-term effects.	• Funding levels and timing. • Institutional capacity (e.g., data, models, expertise, organization). • Public perceptions.	Short-term resource availability (e.g., firefighters from other jurisdictions).

Stakeholder Assessment	Understanding of scientific explanations and logic.	• Representativeness of stakeholder groups. • Desired and minimum acceptable outcome levels and their relative importance. • Stability of stakeholder preferences over time. • Willingness of stakeholders to compromise.	Changing societal needs and priorities.

Obviously, much is uncertain and largely uncontrollable in this decision environment. While it is true that some uncertainties can be reduced over time through better science and organizational learning, many—if not most—uncertainties cannot be eliminated altogether.

The Uncertainty Dilemma

In describing and representing the scientific and stochastic uncertainties inherent in problems such as the Sierra Nevada Forest management decision, analysts face a dilemma. On the one hand, simple and accessible characterizations of the multiple uncertainties are likely to be misleading, biased, or wrong. For example, recent graphs generated by the Sierra Nevada Forest Plan Amendment (SNFPA) Review Team depict likely outcome trajectories of different management strategies over the next 140 years as lines (Barber 2003). At a meeting of owl scientists held in early 2003, objections were raised that such linear depictions may be misleading because they suggest that these trajectories are or can be known with certainty, or at the very least that depicted differences among these lines are real and meaningful. Those objecting argued that confidence intervals should be placed around each line, and that doing so would likely show that depicted differences in expected outcomes are significantly more uncertain than what the simple graphs suggest. Whether or not the objection is valid, the point remains that lack of detail was perceived to be at minimum misleading, likely biased, and perhaps even wrong.

On the other hand, the alternative poses its own challenges: detailed characterizations of uncertainty are likely to be difficult to understand and present, and consequently may not be useful to the public or to decision makers. Hence, there is no scientific or technical solution for handling uncertainty; resolution depends on the decision processes employed. Recent literature reveals that to be effective under large-scale uncertainty such as in the SNFPA case, such processes must tightly integrate analysis and broader deliberation, and should allow all participants to understand where scientists agree, where they disagree, and where their relative certainty ends (Stern and Fineberg 1996).

RISK

The Social Context of Risk

Risk is a compound measure of the probability and magnitude of some event or adverse effect (Dietz, Frey et al. 2000). While risk can be measured in terms of probabilities and

magnitudes, unlike uncertainty, classifying something as risky is a social construction. Society determines which risks are important and should be attended to. Different individuals and societies perceive risks differently; therefore, our perceptions of what is risky and whether we should do something about it vary across space and time. As mentioned above, different social science disciplines provide us with varied insights into how and why these different perceptions of risk arise. We briefly review some of these disciplinary conceptualizations of risk: those that have had the greatest influence on how risk is perceived in the decisions underlying managing the federal forests.

Psychological Perspective

Until recently, risk perception was dominated by a psychometric approach that focused on cognitive processes underlying risk perceptions. Research indicates that most individuals systematically under- or overestimate risks (Tversky and Kahneman 1982), which may reflect fundamental processes in the cognitive organization of risk perception. A number of common sense strategies or cognitive "rules of thumb" apparently produce these biases. The *availability* heuristic is one of the most important of these rules (Tversky and Kahneman 1982).

Many of these rules of thumb have evolved out of psychological experiments on how humans perceive risk and behave in risky contexts. In some of the classic psychology experiments, participants were presented with "lotteries" and asked about their preferred choices. In an effort to determine individual perceptions of common risk factors, researchers provided subjects with pairs of causes of death and asked them to judge which of the pair is most likely to occur (Lichtenstein, Slovic et al. 1978). For instance, subjects might be asked the following: in each of the following pairs, which cause of death is most likely to occur?

- lung cancer or stomach cancer?
- murder or suicide?
- diabetes or motor vehicle accident?

People tend to answer that lung cancer is responsible for more deaths than stomach cancer, murder for more deaths than suicide, and diabetes for more deaths than motor vehicle accidents. In fact, aggregate data indicate that the second alternative for each pair (stomach cancer, suicide, motor vehicle accidents) is one-and-a-half times more likely to occur than the first alternative. People typically err in making two out of the three probability choices. The availability bias in this context, then, means subjects find one of the explanations "more readily available" and therefore select it as the possible explanation. One persistent conclusion of these psychological experiments and observations in actual life is that laypersons are not very good at assessing the risks they face (Lichtenstein, Slovic et al. 1978).

Why are laypersons' judgments sometimes correct, but more often incorrect? What cognitive processes could produce such contrary results? Fishhoff and Lichtenstein et al. (1981) and Tversky and Kahneman (1982) propose the availability heuristic as an answer. The extent to which an event is cognitively available—that is, vivid and easy to recall—strongly influences the event's perceived probability. The familiar is seen as

more probable than the unfamiliar, and recent events more probable than past events, other things being equal. This suggests that people tend to overestimate the frequency of unlikely events with dramatic consequences because the drama of such events makes them cogitatively available and thus easier to recall. In addition, people will typically overestimate causes of death that are highly publicized (Combs and Slovic 1979; Sandman, Sachsman et al. 1987), such as lung cancer and homicide, relative to less-publicized but more frequent causes of death, such as stomach cancer and suicide. The availability heuristic, with its emphasis on recency, produces a biased perception.

Discrepancies between public and expert perceptions of risk are seen in information about risk, and in laypersons' tendency to stress qualitative features of risk ignored by experts. For example, risks highly dreaded by the public are those perceived to involve lack of control, including voluntary vs. involuntary risks, catastrophic potential, fatal consequences, and/or inequitable distributions of risks and benefits. Such risks are far less acceptable to the public than to experts (Slovic 1987). In fact, discrepancies in lay and expert judgments of risk are based on different definitions of risk (Dietz, Frey et al. 2000).

If the public and the experts have different views of risk, of what value is public opinion to risk evaluation? And what is the proper role of the public in risk management? Three positions are described in the literature. The first position argues that the public should be excluded from risk assessment and decision making (Starr 1969; Cohen 1987; Breyer 1993). The second position proposes that laypersons' perceptions of risk should be brought in line with the experts'. Advocates of this view call for policy makers to improve communication between agencies and the public, to educate citizens so they are better prepared to evaluate uncertainties, and to develop better risk management strategies that include means for providing the public with accurate, understandable information on which to make reasonable decisions (Covello, Sandman et al. 1989).

The third position recognizes that nearly all risk assessments and risk management strategies are laden with uncertainty and meta-uncertainty, that experts as well as the public are subject to cognitive biases, and that an emphasis solely on technical information has political implications for the relative power of different interest groups. For these reasons, laypersons should play a more central role in the process of assessing, evaluating, and managing technological risks (Perrow 1984; Dietz 1987; Freudenburg 1988; National Research Council 1989; Fischhoff 1990; Brown 1992; Brown 1997; Rosa and Clark 1999). In developing the Sierra Nevada forest management plans, the Forest Service has been increasingly implementing this position by attempting to involve multiple stakeholders in its deliberations. Unfortunately, as we discuss later in this report, public participation does not always ensure agreement on the perception and relative importance of the risks.

Sociological Perspective

The sociological perspective seeks to understand social influences on risk perception and behavior, the importance of organizational contexts and institutional responses to risk,

and the role of risk in large-scale social change. Four distinct research directions, representing increasing levels of theoretical aggregation from micro to meso to macro, are described according to this perspective.

The first direction builds upon psychometric research, but its goal is to reconceptualize the psychometric finding through a sociological lens (Dietz, Frey et al. 2000). The most serious problem with this approach is the absence of research on whether risk perceptions predict actual behavior.

The second sociological research direction fundamentally reconceptualizes the psychometric model by proposing a model that examines the problem of risk perception by taking into account the social context in which human perceptions are formed (Rosa, Mazur et al. 1987). The model assumes that humans do not perceive the world through pristine eyes, but through perceptual lenses filtered by social and cultural meanings transmitted via primary influences (family, friends, coworkers) and secondary influences (public figures, mass media). Moreover, this perspective notes that people often take action or form attitudes prior to developing meaningful perceptions. The underlying psychometric model ignores this fact, but it is a central feature of this sociological model.

The organizational and institutional approach emphasizes the system characteristics, the context of complex issues (environment, technology), and the policies that develop for their use. According to this direction, risks can only be understood by analyzing the way parts of risky systems fit together (Freudenburg 1988)—a sociological focus on the organizational and institutional contexts of decision making.

The fourth line of thinking deals with worldwide social change: the transformation from modernity to its successor, some form of postmodernity. Risk is the central driving force of this transformation (Giddens 1990): modernity results in globalization. That is to say, there is a worldwide spread of risks associated with production processes, and a worldwide diffusion of consumption practices and their accompanying risks. Shared risks, such as global warming and ozone depletion, are globalized risks—not contained within national borders. This global interdependence grounded in shared risks magnifies the importance of trust. Giddens' argument is similar to Beck's (1992) "reflexive modernization," and distributing "bad" dangers, that form the basis of "the risk society." This social change results in a decline in the importance of structures, and the individualization of social agents who, forced to make decisions, reflect on the social institutions responsible for those decisions. Like Giddens, Beck defines risk globalization and emphasizes the role of trust in dealing with them. In addition, Beck underscores the role of science in issues of risk, a facet emphasized by other scholars as well (Dietz, Stern et al. 1989; Brown 1992; Burns and Dietz 1992). On one hand, science is partly responsible for the growth of risks and hazards; on the other hand, science is the principal social institution entrusted with knowledge claims about risk. Since science is no longer privileged, risk societies make knowledge claims about the increased risks defining societies through Beck's "reflexive modernity," that is, a negotiation of knowledge claims between science, political interests, and laypersons. This reduced status for science, and the relative increase in the ability of different community groups to

form coalitions that challenge administrative action, is a relatively new phenomenon. We have yet to develop the institutions and mechanisms that provide the stability and trust necessary for developing and implementing approaches to addressing complex long-term problems.

Anthropological Perspective

The anthropological approach to risk analysis incorporates cultural theory. In comparison with the psychological perspective, the anthropological approach emphasizes shared beliefs and values, or the cultural construction of cognition, in determining not only the problem definition, but also means–end perception and ex-post evaluation. According to Marsella (1998), culture is "Shared behavior that is socially transmitted…. Culture is represented externally in artifacts, roles, institutions, symbols, and activity contexts. Internally, culture is represented in beliefs, values, attitudes, consciousness patterns, and meanings." In contrast with the behaviorism tradition, cultural theory focuses on the intersubjectivity among the population, and the construction of risk perception has to be contextual and socially based. Risk can be linked to culture in multiple ways.

Douglas and Wildavsky (1982) argue that selecting risks for societal attention is purely a social process with little or no linkage to objective risk or physical reality. Popular risk analysis is to assess the probability of risky events, yet cultural theory first answers the question "what is the risk?" Social disagreement over defining risks is the fundamental source of uncertainty, and the multiple and dynamic characteristics of culture make it impossible to reach a full compromise in terms of cultural cognition in almost every public policy.

Swedlow (2002) reframed the typology proposed by Douglas and Wildavsky (1982) to identify four patterns of cultural biases and their relation to basic risk understanding and to risk management strategies. The *individualistic* pattern values liberty, autonomy and equilibrium through dispersed behavior. Thus, risks stem mainly from bounded individual rationality and from undue intervention of central control. The *fatalistic* pattern relies on random luck and demands merely survival: risks stem from uncontrollable contingencies. The *hierarchical* pattern values order and collective acts under a central plan: risks result from absence of concentrated coordination. Finally, the *egalitarian* pattern values equality within not just the human community, but also between the social and natural communities. These patterns may well shape how individuals interpret potential problems and their policy implications. Yet, the relative distribution of the population into these four groups is far from clear or fixed. The zero-sum nature of some decision-making rules based on cultural values may well be the harbinger of future contingencies because of the different patterns' changing relative influence.

In addition to the four patterns based on basic social philosophies, cultural biases can come from cultural distinctions between departments, regions, occupations, educational backgrounds, socioeconomic status and other cultural entities. While risk perception of

the same public issues is segmented, the cultural risk of decision making is a risk of consensus, or the risk of legitimacy. Yet, such cultural consensus cannot be easily achieved by political compromise, since culture may not constitute a conscious variable in decision-making processes. Generally, cultural risks in decision making have the following patterns: first, relatively homogenous decision environments may change or become pluralistic over time; second, pluralistic decision environments may change either because of restructuring the relative importance of different cultural components, or because of changing participants. The cultural environment is dynamic, and its influence on risk perceptions—including identifying and defining the problems, their seriousness and the maximum risk level that the society can tolerate, the proper ways to mitigate risk, and evaluating costs and benefits—consequently have to be dynamic and mixed.

Current criteria for social justice, such as the Utilitarian or Rawlsian notion of justice as fairness, must be based on measurability of the target constructs, either in reality or at least in imagination. Yet cultural risk, like the other risks discussed here, is not measurable in both senses. Since there is no absolute criterion for judging and ranking cultural stances, risk aversion implies making open-ended decisions that try to incorporate every value orientation and to allow for the possibility of expanded application. For complex situations with multiple cultural backgrounds involved, such pragmatic open-ended decision making brings about excessive cost and slow decision making.

In a democratic society, slow decision making coupled with the potential for changing political support creates uncertain and unstable environments in which administrators need to make decisions that have long-term implications, both in terms of implementation and consequences. In situations such as forest management, where management programs are implemented over a period of years and their consequences are not knowable for even longer times, over time such variability regarding support for decisions is a source of tremendous uncertainty. The risks associated with such administrative uncertainty are often referred to as "administrative risk."

Economic Perspective

Economic risk analysis does not concern itself with the social construction process of risk perceptions (they are considered to be given), but focuses on risk measurement, evaluation, forecasting, controlling and decision making, using economic techniques and methods. Thus, the definition of risk is mainly technical, such as "risk is the variation in outcomes around an expectation" (Fone and Young 2000). It is also dynamic since hazards result from combining various alternatives (or natural states) with multiple possible outcomes. Generally, in risky situations, the probability distribution of such outcomes is known. Expressed in financial or economic terms, risk is linked to losing money, profit, or wealth.

Economic decision making linked to risk has two steps: to identify the possible consequences of action or non-action, and to chose the action based on comparing these

consequences using some pre-established criteria. In reality, the knowledge of alternatives, consequences, and probability distribution is far from complete, so rational decision making can only be incomplete and fragmented (Simon 1960). Generally, the economic approach concentrates on analyzing possible monetary loss, or on analyzing the comparison between costs and benefits, using methods like net present value, cost-benefit analysis, impact analysis, or the relatively recent value-at-risk analysis. Risk typologies vary according to the characteristics of risk sources: systematic risk or random risk, statistical risk or non-statistical risk, internal or external risk. Jorion (1997) classifies financial risks as market risks, operational risks, liquidity risks, credit risks, and legal risks. Another way to classify risks is to compare two types of risk undertakers: individuals and agencies that have different risk perceptions, decision procedures and risk control methods.

The economic approach operates as if the economic value (cost) of risk can be accurately measured. This assumption is also seen as this perspective's major problem since benefits or costs cannot be measured directly through monetary units, especially when considering social and ecological costs or benefits. The value of commodities for which there are no markets can be imputed by people's willingness to pay. For example, people moving into a safer neighborhood may have to tolerate higher real estate prices. Assuming all other things constant, the increased housing expense may reveal their valuation of increased safety. Similarly, social surveys can be used to determine compensation value. Although the validity of such preference revelations are hotly debated, economists argue that they are more reliable than any other form of direct measurement (Fisher and Chen 1996).

Applying economic risk analysis in public decision making is complicated and may be misleading. Some of this difficulty arises from the fact that for multi-goal decision making, decentralized decision making, and decision making that involves mainly non-marketable public supplies and services, the economic perspective requires consistent transformation of risk perceptions into comparable quantities, and the ability to pool such perceptions. As some of the other perspectives illustrate, economic considerations are only one of a number of types of risk that people consider when evaluating decisions under uncertainty. Establishing a forest's economic value is a close-to-impossible task. The valuation has to be done not only for stakeholders in the forests' immediate vicinity, but also for current and future generations of potential stakeholders whose stake is in these forests' very existence.

Geographic Perspective

Geography traditionally researches human responses to natural disasters and human activities in a spatial context (Dietz, Frey et al. 2000). The "social amplification" framework borrowed from communication theory attempts to link risk perception and behavior (Machlis and Rosa 1990). Classic communication theory emphasizes a source–receiver model in which signals are sent from a source to a receiver. The message gets intensified or attenuated by the intermediate transmitters. Thus, signals leaving the source will be altered during transmissions to the ultimate receiver(s). The social

amplification of risk follows the same procedure. Risk events are signals that are amplified before reaching the ultimate receiver: the public. The amplification may be either heightening or attenuating the risk. Principal amplifiers include information processes, institutions, social milieus, and individual experiences. Since amplifying risk signals is due to cognitive heuristics, the framework attempts to bring together psychometric findings on risk perception with the institutional context of risk communication in order to better predict responses to risk.

The geographic perspective emphasizes issues of location and place, thereby highlighting yet another factor that must be taken into consideration when making decisions. Local communities often attach special meanings to specific locations (Putnam, Leonardi et al. 1993). Lack of knowledge about local sensibilities can cause problems when attempting to implement decisions taken in the absence of such information.

Integrating the Multiple Perspectives

These different social science perspectives on risk are, by definition, only illustrative of risk's complexity as a theoretical notion, and its operationalization in the different disciplines. Our summaries do not, by any means, exhaust the multiple perspectives and their obvious and subtle differences. The lesson to be drawn from these brief sketches is that even in the simplest decisions there are a number of theoretical issues to be taken into account as one considers decisions under uncertainty.

For public decision making, a prudent approach is to first analyze the direct costs and benefits associated with risks, and then to identify the possible social consequences together with their implied value(s). Public deliberation about these consequences and their valuation could potentially lead to improved decisions.

The Risk Dilemma

How people perceive risk depends on (Tversky and Kahneman 1982):

- what they value,
- how the risk is framed, and
- their level of trust in the responsible organization or institution.

It is well known, for example, that there is an inverse relationship between perceived risk and perceived benefit, and this relationship is linked to an individual's general affective evaluation of a hazard. If an activity is "liked," people tend to judge its benefits as high and its risks as low. If the activity is "disliked," the judgments are the opposite—benefits tend to be perceived as low while risks are perceived as high (Slovic 2000).

Further, and perhaps even more important, every way of presenting risk information is a "frame" that can shape participants' judgments in a risk decision. If the issue is framed in a positive light, people are more likely to dwell on the decision's positive aspects, and vice versa. One often-cited example is the observation that summarizing medical risks in terms of mortality rates yields very different perceptions than when the same information

is presented in terms of survival rates. If a given treatment is described as having a mortality rate of 10%, for example, it is perceived very differently than if the same treatment is said to have a survival rate of 90% (Tversky and Kahneman 1982). Evidence also shows that experts are not immune to these framing effects: The effect is as strong when subjects are physicians as when they are lay people. As the National Research Council report concludes, "Numerous research studies have demonstrated that different but logically equivalent ways of summarizing the same risk information can lead to different understandings and different preferences for decisions"(Stern and Fineberg 1996, p. 57).

Note that this is not an issue that can be resolved with better science, because there is no scientific way to determine that one risk summary is more accurate or less biased than another when both accurately reflect the same data. Consequently, the problem of generating a single unbiased risk information summary to meet participants' needs in a risk decision has no purely technical solution. In the SNFPA case the problem is further complicated by the fact that there is not one but many sources of uncertainty that give rise to multiple risks. Forest fires are risky for humans, for the natural habitats of various animals, birds and other creatures; they also pose a risk to streams, trees, and other vegetation. Regardless of how we choose to value them, we have no consensus on the potential consequences of a fire.

As with uncertainty, resolving this type of dilemma requires focusing on the decision processes employed. In this light, it is also important to note a corollary to the affective evaluation principle mentioned above: if participants trust the organization presenting the risk information, they are more likely to accept the characterization. And that level of trust is a byproduct of the decision process. Experience in a variety of settings suggests that such trust is easily damaged and difficult to restore (Douglas 1985). The risk dilemma's relevance to the SNFPA case will be discussed later in this chapter along with the discussion of risk communication.

Risk in Environmental Issues

Risk is a situation or event in which something of human value (including humans themselves) has been put at stake and where the outcome is uncertain. Risk implies the *possibility* and *uncertainty* of some outcome (Jaeger, Ortwin et al. 2000), and is tied to human agency in that it involves choices among different alternatives. Anticipating the consequences of the different possibilities, evaluating their desirability, and choosing the most desirable option lie at the core of human agency. These in turn lie at the core of the Rational Actor Paradigm (RAP), which serves as the foundation of inquiries into risk and uncertainties. One of the most challenging topics for the RAP is *risk.* Three recent Nobel memorial prizes in Economics were awarded to researchers (Simon, Becker, and Selton) whose work relates to issues of uncertainty and decision making related to RAP.

Risk is a concept with a long pedigree in a variety of disciplines, but in virtually all technical discussions, risk is represented as having three components:

- one or more potential stressors (sometimes called hazards),

- a probability that these stressors will occur (often called exposure), and
- the likely adverse effect that will result if the stressors do occur.

It is common to compare risks based on the product of the magnitude of the loss that will occur, and the probability of its occurrence. Such calculations are referred to as "expected values." In a recent example produced by the National Academy of Public Administration (NAPA) (Fairbanks, Gardner et al. 2001), the NAPA panel finds that many federal risk assessment methods consider mostly hazards' magnitude. The panel argues that it is necessary to develop methods that clearly include all three components of risk:

- *hazard*: e.g., an area's fuel loading and dryness conditions;
- *risk or exposure*: e.g., the probability of ignition; and
- *value*: e.g., the physical, social, and economic costs of the potential damage.

Slovic (2000) made an important observation regarding the role of value judgments in assessing risk, which is incorporated into a recent study by the National Research Council (NRC) (Stern and Fineberg 1996). In any characterization of risk, these studies argue, two critical value judgments are at least implicit. First, there is the judgment that a particular process or outcome merits serious attention. The decision to focus on wildland fire hazards or old-forest owl habitat, rather than, say, the economic vitality of adjacent communities or potential harm to black oaks, is a value judgment made by key actors. Because of those key actors' political power and influence, one set of values prevails in characterizing the risks in a given decision. Other actors at different times could have made, and have made, different judgments. Second, there is the judgment about what constitutes an unacceptable outcome. To say that some number of acres of stand-destroying fires is unacceptable reflects the decision-makers' values.

Between these two judgments, there is much room for analysis in modeling, measuring, and calculating, but these important analytical efforts should not obscure the central observation that focusing on some outcomes and not others, and on some outcome levels and not others, reflects the value judgments and priorities of those making the decision. Again, which perceptions prevail in determining acceptable threshold levels of risk is a function of the key actors' influence. Simply, these choices are neither objective nor purely scientific, nor could they be.

Risk in the Case of the Sierra Nevada

In the Sierra Nevada case, we define risk as an expression of the decision makers' values. Note that the important short-term risks facing the Forest Service are related to decision processes, not ecological outcomes. The NAPA discussion (above) is therefore useful in helping to characterize the risks facing the Forest Service in the Sierra Nevada, which are somewhat broader than fire management:

- *Long-term risk*: given observed ecosystem conditions, existing external human factors, and future natural events and processes, the probability that any particular adopted management strategy will result in a preponderance of outcomes judged undesirable by the majority of stakeholders over the long term (beyond 10 years).

- *Short-term risk*: given observed ecosystem conditions, existing external human factors, and future natural events and processes, the probability that any particular adopted management strategy will be seen as undesirable by the majority of stakeholders over the near term (10 years) because
    - it results in a preponderance of undesirable outcomes, and/or
    - it violates accepted historical precedents, and/or
    - it violates widely held principles and standards of practice, and/or
    - it violates broadly held social preferences.

Short-term risks involve much more than just concern about uncertain outcomes or the decision's products. From our own interactions with members of the Forest Service and other related agencies and the public, we learned that while stakeholders are certainly concerned with ecological outcomes, many are willing to accept modest short-term habitat losses if potential long-term gains are great enough. Further, in the short run (10 years), none of the vegetation models or fire projections shows a significant difference in ecological outcomes (Barber 2003). Although these models suggest differences in the long-term, there is sufficient uncertainty about these differences occurring—meaning these differences may be more apparent than real. If it is true both that stakeholders are willing to consider short-term tradeoffs, and that alternatives under consideration are indistinguishable in their short-term outcomes, then the focus of short-term risks must shift to concerns with the decision process.

In paraphrasing Schön (1967), Hellström and Jacob (2001, p. 1) suggest that "every action converts the uncertainty about what to do into the risk of doing it wrong." If action is to be a negotiated outcome of a deliberation among stakeholders, then attention must be paid to process. Otherwise, the decision maker runs the risk of failing even though the likelihood of desirable long-term outcomes is enhanced. And this potential for perceived failure makes the "risk dilemma" all the more relevant.

Risk Communication

The Forest Service faces randomly occurring forest fires, uncertain scientific information about their consequences, and uncertain budgets with which to fight them. These potentialities make up a small percentage of the myriad uncertainties Forest Service administrators have to deal with on a regular basis. The preceding discussion on the different risk perspectives highlights the need for clarity in communicating about risk. Although the formal concept of risk and, consequently, communications about risk, dates back to at least 3200 BC, the formal study of risk communication began fairly recently (Davies, Covello et al. 1987; Krimsky and Plough 1987; National Research Council 1989; Leiss 1996). It has been suggested that risk communication is often neglected, taken for granted or treated as an afterthought (Chess, Salome et al. 1995a; Chess, Salome et al. 1995b). Slovic (1993, p. 676) called the field "young and still primitive." More recently, the risk communication field was characterized as "small" and "immature" when compared to other sciences (Bostrom and Löfstedt 2003). This lack of theoretical development in the risk communication field is reinforced by the lack of

consensus surrounding its definitions, its indications for practice, or a widely agreed upon theoretical framework (Chess, Salome et al. 1995a; Chess, Salome et al. 1995b).

This lack of consensus reflects the reality of the multiple uses of risk communication across academic disciplines, industry, and government, as well as the types of environmental, safety, health, economic, social or political risks it is designed to address. The goals of risk communication may be to inform, persuade, change behavior, provide an immediate emergency response, or contribute to resolving a complex and controversial risk decision (Covello, Sandman et al. 1989; Presidential/Congressional Commission on Risk Assessment and Risk Management 1997). Depending on the specific goal of risk communication, its conceptualization and practice may vary dramatically. For example, the public relations researcher may view risk communication as a persuasive tool designed "to minimize harm to the organization in emergency situations that could cause the organization irreparable damage" (Williams and Olaniran 1998). Alternately, in the health field, a risk communication researcher may view risk communication as a tool to facilitate informed choice in the doctor–patient relationship (e.g., Gordan-Lubitz 2003). A sociologist may bring yet another perspective, suggesting that risk communication is always organizational in nature, limiting an individual's choice of risk communication options (Chess 2001).

Within government agencies, conceptualizations of risk communication may vary depending on agency mission, activities, and the particular type(s) of risk communicated. For example, the goal of risk communications from the Centers for Disease Control regarding preventing the spread of the AIDS virus may be to change behavior. Alternately, the Department of Homeland Security's Federal Emergency Management Agency's goal of risk communications following an earthquake may be to stimulate an immediate and dramatic emergency response among affected individuals and organizations. In the case of the USFS and the SNFPA decision process, risk communication is being utilized in an attempt to contribute to resolving the complex risk decision processes surrounding managing the Sierra Nevada Forests.

We focus on using risk communication as a tool used to inform interested and affected parties in order to contribute to resolving complex risk decisions. Even within this limited context, risk communication has gone through a number of stages as people have learned that it entails a lot more than simply transferring information from a well-informed source to a less informed source. Fischhoff (1995, p. 138) suggests that risk communication has evolved though the following eight stages:

1. All we have to do is get the numbers right.
2. All we have to do is tell them the numbers.
3. All we have to do is explain what we mean by the numbers.
4. All we have to do is show them that they've accepted similar risks in the past.
5. All we have to do is show them that it's a good deal for them.
6. All we have to do is treat them nice.
7. All we have to do is make them partners.
8. All of the above.

Fischhoff (1995, p. 137) notes that while it may seem apparent that any organization should communicate risks utilizing the latter stages, many organizations involved in their first risk communication experiences will very likely start at the beginning of the process. If the organization is to survive, it will quickly realize that the early stages are not adequate to effectively communicate risk, and will rapidly progress through the remaining stages. Alternatively, progressive organizations may "short-circuit" the evolutionary process of risk communication by immediately implementing risk communication practices from the latter stages.

Leiss (1996, pp. 87, 90) provides a chronological perspective in describing the evolution of risk communication over the last 30 years. He divides this evolution into three phases:

- "Phase I (about 1975-84) stressed the quantitative expressions of risk estimates and argued that priorities for regulatory actions and public concerns should be established on the basis of comparative risk estimates.
- Phase II (about 1985-94) stressed the characteristics of successful communications: source credibility, message clarity, effective use of channel, and above all, a focus on the needs and perceived reality of the audiences….
- Phase III (1995 onward) is characterized by an emphasis on social context, that is, on the social interrelations between the players in the game of risk management."

Leiss acknowledges Fischhoff's eight-stage learning process, approximating his Phase I to Fischhoff's stages one and two, his Phase II to stages three through six, and his Phase III to stages seven and eight.

We propose a three-stage typology of risk communication as a process, building upon Fischhoff's and Leiss's contributions, and using the almost 10 additional years of discussions in the literature that provide further insight into the theory and practice of risk communication. This characterization of the three stages of risk communication process is:

- **Stage I: One-way risk communication**
- **Stage II: Two-way risk communication**
- **Stage III: Participatory risk communication**

These three stages are intentionally broad to capture the full range of both risk communication theory and risk communication practice as they apply to resolving complex risk decisions. It is important to note that while there is an evolutionary progression from Stage I through Stage III, the stages are not meant to be mutually exclusive. In fact, each stage includes and goes beyond the previous stage's risk communication practice. Thus, an agency may employ any one or even a combination of these stages depending on the agency's attitude towards risk communication, the type of problem being addressed, and the risk decision process being employed to address that problem.

Before describing each stage of risk communication in more detail, it is first necessary to provide a brief overview of common risk decision processes as a background for our three stages. Next, we will present a detailed overview of each stage of risk

communication's development, including strengths, weaknesses and conceptual definitions of key terms. With this framework for considering risk communication in place, we will review and characterize the risk communication practices that have been employed to address the SNFPA decision problem.

Risk Decision Processes

Of particular interest in evaluating the theory and practice of risk communication is the observation that the stage of risk communication utilized by an organization relies on the underlying risk decision process. Since the notion of risk has slightly different characterizations, depending upon its disciplinary basis, many overlapping and sometimes conflicting definitions of terms exist, such as risk assessment, risk analysis, risk characterization, risk evaluation and risk management. Understanding that there is not always agreement on these definitions, we simply propose the following definitions and use them as a frame of reference for the sake of clarity.

- *Risk Assessment*: "The quantitative and/or qualitative scientific analysis and characterization of adverse effects of environmental hazards" (National Research Council 1983, p. 18; 1996, p. 33).
- *Risk management*: "The process of weighing policy alternatives and selecting the most appropriate regulatory action, integrating the results of risk assessment with engineering data and with social, economic, and political concerns to reach a decision of alternative regulatory actions and selecting among them" (National Research Council 1983, p. 3; 1996, p. 33).

Gerrard and Petts (1998) review the continuum of different characterizations of the risk decision processes that has developed over the last 30 years. One end of this continuum features the strict conceptual separation of risk management and risk assessment—the "traditional view" of the risk decision process. The other end of the continuum features completely integrating risk management and risk assessment— the cultural relativist view. In the middle of this continuum are many different "blended" risk decision processes that integrate and separate risk assessment and risk management to varying degrees.

Traditional Risk Decision Process

In the "traditional view" of risk decision processes, risk assessment is the process of "understanding" the risks associated with a decision by scientists and risk analysts (National Research Council 1983; 1994; 1996, p. 33). Risk assessors are expected to work only within the realm of positivist rationality. Isolated from subjective political, social and regulatory value judgments inherent in risk management, the risk assessors use objective science to summarize the risks associated with specific hazards. One commonly used example of this "traditional view" is contained in the National Research Council's 1983 *Risk Assessment in the Federal Government: Managing the Process*, commonly referred to as the "Red Book." Although presented in the context of risk decisions made by agencies to protect human health, their model is useful in illustrating a separated risk decision process and has been used often to do so (e.g., National Research

Council 1994; 1996; Presidential/Congressional Commission on Risk Assessment and Risk Management 1997; Gerrard and Petts 1998). In this model, the NRC (1983, pp. 18-22) suggests that risk assessment is typically a four-step process consisting of:

- *Hazard identification*: "involv[ing] characterizing the nature and strength of the evidence of causation";
- *Dose-response assessment*: "the process of characterizing the relation between the dose of an agent administered or received and the incidence of an adverse health effect in exposed populations and estimating the incidence of the effect as a function of human exposure to the agent";
- *Exposure assessment*: "the process of measuring or estimating the intensity, frequency, and duration of human exposures to an agent currently present in the environment or of estimating hypothetical exposures that might arise from the release of new chemicals into the environment" and
- *Risk characterization*: "the estimation of the probability of negative effect based on the dose-response and exposure assessments and a summary of all relevant risk assessment information."

The final step of the risk assessment process, *risk characterization*, summarizes the hazard identification, dose-response and exposure assessments. Once the assessment is complete, risk managers synthesize the estimations of probabilities of negative effect contained in a risk characterization with the social, political and regulatory restraints surrounding a particular risk (National Research Council 1983; 1994). The result of this synthesis is manifested in a final risk decision. After the decision is made, the risk managers ensure the decision is implemented and evaluate its impacts.

Note that despite the conceptual separation of risk assessment and risk management, even proponents of the traditional view do not assume that risk assessment is value-free. It is further acknowledged that risk assessors are often required to make many different value judgments in many instances across the risk assessment process, particularly when there is a lack of scientific consensus or when available data are not complete or conclusive (National Research Council 1983, 1989, 1994, 1996; Slovic 1987, 1993; Hance, Chess et al. 1988). Examples of these judgments include determining what level of statistical significance to use in evaluating survey results; deciding how to incorporate multiple, equally credible studies with differing research approaches and outcomes into analysis; determining the types and numbers of possible confounding factors that should be considered; and determining if research conclusions based on samples are applicable to the affected population(s) (National Research Council 1983). To address the types of value judgments inherent in risk assessment, the "Red Book" suggests that agencies implement "inference guidelines" to provide assessors with a systematic way to address value judgments as they arise. The guidelines are based on both agency policy and generally accepted scientific principles (National Research Council 1983, p. 63; 1994, pp. 28, 79).

While risk assessment in the traditional view is understanding risk, risk management is the "action" of this risk decision process, incorporating the evaluation of regulatory options and agency, political and social realities by the agency and risk management

experts (National Research Council 1983; 1994; 1996, p. 33). Risk managers are "supposed to deal with broad social, economic, ethical and political issues in choosing from among a set of decision options using the results of the risk assessment and their understanding of the other issues" (National Research Council 1996, p. 33). The risk decision is made by combining both the scientific options resulting from the risk assessment and the evaluation of the regulatory, agency, political, and social realities in risk management.

Culturally Relative Risk Decision Processes

In the culturally relative type of risk decision process, risk assessment and risk management are completely integrated (Gerrard and Petts 1998, p. 3). Here, the assumption is that "science and the scientific process are inextricably linked to subjective value judgments; that science is bound-up with political and social institutions and is thus unable to be wholly objective." At the extreme, this model proposes thinking that gives equal value to every voice in the risk decision process, regardless of credibility, sincerity, or interest in the process. The focus is on deliberation that may or may not be informed by scientific analysis. Operating under this assumption, the science of risk assessment may be devalued to the point where it may become almost meaningless in the risk decision process.

Blended Risk Decision Processes

In the middle of these two extremes, Gerrard and Petts (1998) suggest that there are many different "blended" risk decision approaches. One such approach, characterized as "scientific proceduralism," from Shrader-Frechette (1991) "focuses upon a blend of robust scientific and technical analysis, effective communication and stakeholder involvement" (Gerrard and Petts 1998, p. 3; Crawford-Brown 2001). A similar "blended" approach is outlined in the Presidential/Congressional Commission on Risk Assessment and Risk Management (1997), which proposed a risk decision process that focuses on "cumulative risks to human and environmental health and on addressing the benefits, costs, and social, cultural, ethical, political, and legal dimension of risk reduction options" (p. ii). This decision process acknowledges risk assessment as a critical part of the risk decision process, but also stipulates that risk assessors should "note the subjective, cultural, and comparative dimensions" inherent in the assessment process (p. 21).

Another recent example of risk decision processes that blends risk assessment and risk management together into the risk decision process may be found in the NRC's 1996 report (1996, p. 35). The risk decision process proposed advocates risk decisions based on an analytical-deliberative process that "emphasizes…there is a role for both scientific method and for appropriately broad-based deliberation." Here, deliberative processes involving both public officials and interested and affected parties inform the value judgments inherent in scientific analysis. In addition, the final risk decision includes the agency, the scientific community, and interested and affected parties—all are treated as

equal partners. This is significantly different than the traditional risk decision process, where the final risk decision is always solely within the agency's domain.

As will be shown below, conceptualizing risk communication in theory and practice relies on what type of risk decision process is being used in an agency's approach to a particular risk decision. We now highlight the three stages of risk communication practiced by agencies over the last 30 years, again reiterating that while the stages have evolved from the Stage I through Stage III in theory, in practice agencies may be utilizing any one or a combination of the three.

Stage I: One-Way Risk Communication

Stage I one-way risk communication is associated with a traditional risk decision process and is implemented by agencies to comply with legal requirements requiring transparency into agency activities, and community and citizen "right to know" stipulations. Communicating risk in this stage generally consists of releasing probabilistic risk statements from agency experts to affected parties.

In this stage, risk communication is not conceptualized as a formal or distinct activity within the risk decision process; therefore, the same risk assessment and risk management experts responsible for the risk decision are also responsible for communicating the risks associated with that decision to the public. Because the releases of information in this stage are made primarily to be in compliance with law, they are strictly one-way. Feedback from non-experts is not contemplated to be necessary or important. Once non-experts are informed with the probabilistic risk information, the agency experts then assume that the non-experts will understand the justification for the agency's risk decision.

Definition

Stage I risk communication may be defined as the one-way release of information about a hazard from agency experts to interested and/or affected parties.

History

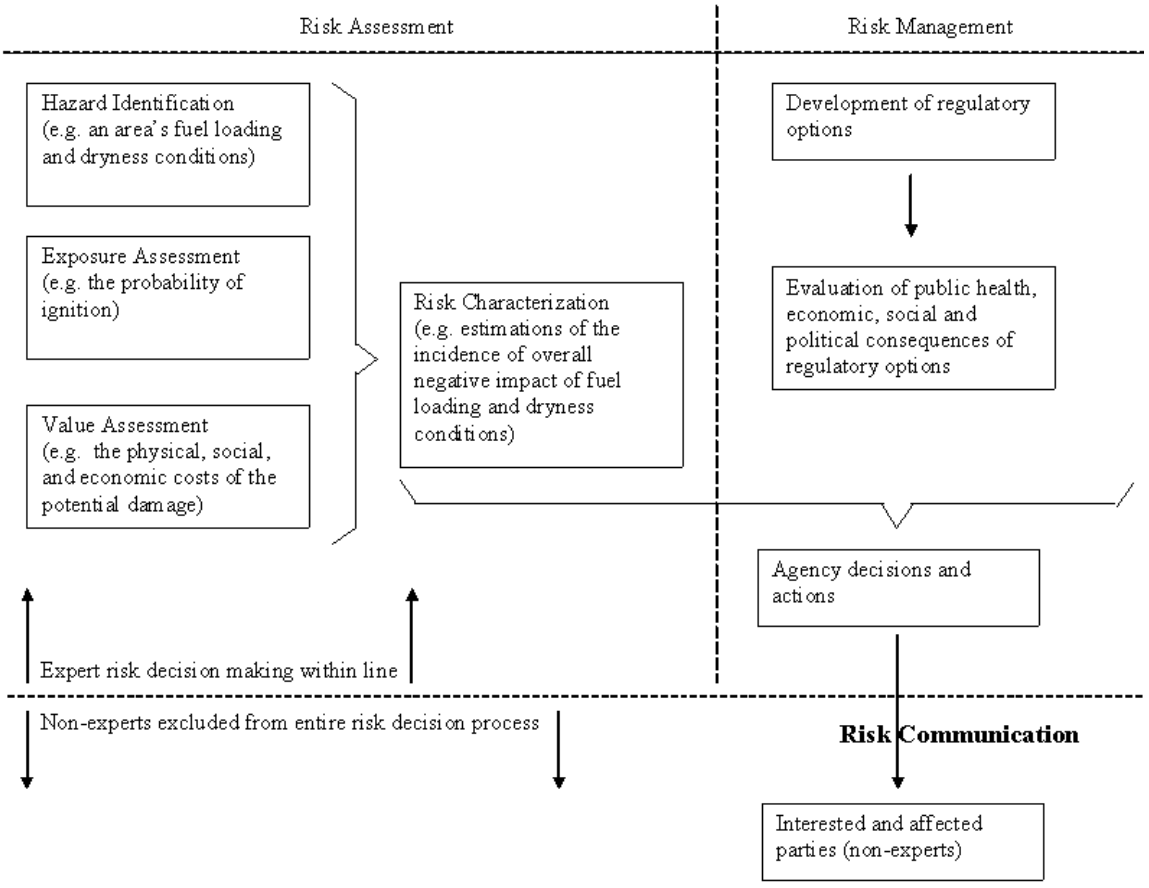
Stage I in theory and practice was the primary conceptualization of risk communication prior to the mid-1980s. Although the theory of risk communication has continued to develop, Stage I risk communication may still be practiced. Stage I one-way risk communication has legislative roots that can be traced back to the Administrative Procedure Act of 1946, which began a trend requiring disclosing agency activities to the public. This trend continued to develop with the passage of the Freedom of Information Act (1966), the National Environmental Policy Act (1969), the Government in the Sunshine Act (1976) and Title III of the Superfund Amendments and Reauthorization Act of 1986 (National Research Council 1989; Peters, Covello et al. 1997; Rosenbloom 2000; Beierle and Cayford 2002). In response to these legislative trends agencies began to develop their first implicit risk communication activities by providing citizen access to

the same information the agency used to complete a risk decision (National Research Council 1989; Peters, Covello et al. 1997).

Stage I Risk Communication and the Risk Decision Process

In Stage I, risk communication is an activity that arises out of a traditional risk decision process. At the end of the risk decision process, the risk decision—made exclusively by the agency—is communicated to interested and affected non-experts. Figure 2 contains an illustration of Stage I risk communication emanating from a simplified model of the traditional risk decision process. The elements of the risk assessment have been simplified to more broadly reflect risk assessment activities outside of those specifically associated with human exposure to toxins as modeled in the NRC's (1983). The three broad components of general agency risk assessment activity are hazard (e.g. an area's fuel loading and dryness conditions,) exposure (e.g. the probability of ignition,) and value (e.g. the physical, social, and economic costs of the potential damage) (Fairbanks, Gardner et al. 2001).

Figure 2: Stage I – One-Way Risk Communication, and the Traditional Risk Decision Process*


Risk Assessment
Risk Management
Hazard Identification (e.g. an area's fuel loading and dryness conditions)
Exposure Assessment (e.g. the probability of ignition)
Value Assessment (e.g. the physical, social, and economic costs of the potential damage)
Risk Characterization (e.g. estimations of the incidence of overall negative impact of fuel loading and dryness conditions)
Development of regulatory options
Evaluation of public health, economic, social and political consequences of regulatory options
Agency decisions and actions
Expert risk decision making within line
Non-experts excluded from entire risk decision process
Risk Communication
Interested and affected parties (non-experts)

*Risk decision model adapted from National Research Council (1983): *Risk Assessment in the Federal Government: Managing the Process, p. 21.* Risk communication depicted in this process is solely the responsibility of the author.

As illustrated in Figure 2, in Stage I risk communication, the underlying risk decision process not only separates risk assessment and risk management activities, but also experts and non-experts. The underlying philosophy of the traditional risk decision process is that the objective science of risk assessment should always be separated not only from the subjectivity of risk management, but the subjectivity of the value judgments made by interested and affected parties

Stage I Strengths

The primary strength of risk communication in Stage I is that *it happens at all*. Although not explicitly acknowledged as a formal part of the risk decision process, the release to non-experts of risk information previously available only to experts in the risk decision process marks the beginning of a trend to acknowledge risk communication, at least implicitly, as part of the risk decision process.

Stage I Weaknesses

Many scholars and practitioners have noted the shortcomings of the Stage I approach to risk communication. These shortcomings include:

- *Risk experts are rarely communication experts*: Because risk communication is not considered as a separate activity within the risk decision process, subject area experts are often thrust into a public communications role for which they are not trained or prepared to handle effectively.
- *Direct inference*: Communicating societal-level probabilities of risk delivered to individuals who are primarily concerned with their own wellbeing led to what Walker (1995) characterized as a "conceptual gulf" between experts and non-experts in risk communication. He suggests that most—if not all—individuals want to understand or directly infer what a statement of population risk means specifically for them: "When a regulator makes a best estimate of the expected incidence of 'one in a million,' a member of the public may be wondering about the probability that a specific individual is *that one* person in a million" (p. 605).
- *Misinterpreting probability data*: Misinterpreting probability data is another potential source of misunderstanding between experts and non-experts (National Research Council 1989). One illustrative example is the differing perceptions of simple probabilities in weather forecasting. In a study cited by the NRC (1989, p. 129), survey respondents were equally likely to associate "a 70% chance of rain" with its true meaning—a "70% chance of some measurable rain"—as they were "rain for 70% of the time," or "rain over 70% of the area."
- *Differing risk perceptions*: Slovic, Fischhoff et al.'s (1980) work on non-expert risk perception suggests that misunderstandings may occur between experts and non-experts in interpreting one-way risk communications due to "multiattribution." The concept of multiattribution implies that individuals perceive risks in more dimensions than those implied by quantitative risk statements (Morgan, Fischoff et al. 2002, p. 10). For example, nuclear power, despite expert assessments indicating a very low probability of death in the population, is often perceived to have an unacceptable level of risk to non-experts

because it exhibits risks that are perceived to be "uncontrollable, dread[ful], inequitable, catastrophic and likely to affect future generations" (Slovic 1987, p. 5). Although it may be the case that non-experts do not have all of the information on hazards and risks that experts have, their conceptions of risk almost always contain "legitimate concerns" that must be accounted for in risk communication and risk management (Slovic 1987, p. 6).

- *Lack of trust*: One possible result of the misunderstandings between agency experts and interested and affected parties attributable to differing perceptions of risk, direct inference, and misinterpretations of probability data is a lack of trust. Agency experts may see non-experts as irrational or ignorant for not accepting their estimates of risk in the population, while non-experts may perceive the experts to be arrogant and unwilling to understand their concerns (Slovic 1987, 1993; Hance, Chess et al. 1988; Leiss 1996).

Stage II: Two-Way Risk Communication

Stage II two-way risk communication, like Stage I, occurs within the context of a traditional risk decision process. However, for agencies in Stage II there are three substantial changes in how risk communication is conceptualized when compared to Stage I. First, risk communication is formally recognized as a legitimate and necessary part of the traditional risk decision process. Second, risk communication practitioners in Stage II recognize that affected parties to a risk decision in a democratic society have "a right to participate in decisions that affect their lives" (Covello, McCallum et al. 1989, p. 85; National Research Council 1989). Third, there is the realization that communication theory may be used to design informative and/or persuasive risk messages to resolve the expert/non-expert misunderstandings that often occur in Stage I. The goals of Stage II risk communication, then, are not only to be in compliance with the law, but to ensure understanding of agency risk communications and to actively involve interested and affected parties in risk decisions.

Although Stage II risk communication practitioners believe that interested and affected parties should have a say in "decisions that affect their lives," it is clear that public participants should *not* "share responsibility for risk management decisions" (National Research Council 1989, p. 155). Public involvement is used as a means to inform expert risk decision making, but falls short of a process where experts and interested and affected parties are equals in the decision process. The final risk decision and risk communication strategies always rely on the agency.

Definitions

The National Research Council's *Understanding Risk Communication* (1989) is one of the classic works on two-way risk communication. In this oft-cited volume the NRC defines risk communication as follows:

> an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions, or

> reactions to risk messages or to legal and institutional arrangements for risk management. (p. 21)

This definition of risk communication is significant in that it reflects the trend in the literature of explicitly acknowledging that risk communication must be considered to be an interactive process. In addition, the NRC report is careful to articulate the difference between risk communication and risk messaging. The NRC (1989, p. 322) defines a risk message as:

> a written, verbal, or visual statement containing information about risk; may or may not include advice about risk reduction behavior; a formal risk message is a structured written, audio, or visual package developed with the express purpose of presenting information about risk.

History

Highly publicized environmental disasters of the late 1970s and early '80s such as Three Mile Island, Love Canal, Chernobyl, and the lethal chemical vapor release of the Union Carbide Plant in Bhopal, India combined with an overall decreasing level of trust in government institutions (see National Research Council 1989, 1996; Slovic 1993; Peters, Covello et al. 1997) lead to increased interest in improving risk communication among risk management practitioners and theorists. This increased interest helped provide the impetus for developing a second stage of risk communication.

The theoretical concept of two-way risk communication first began to be articulated in the 1980. The EPA, widely credited as being the first government agency to formalize risk communication processes, and the most active in improving the process (Krimsky and Plough 1987; U.S. Public Health Service 1995; Chess, Salome et al. 1995b), worked with the National Science Foundation to create one of the first formal conferences on risk communication: the National Conference on Risk Communication (Davies, Covello et al. 1987; National Research Council 1989). This conference marked the beginning of a flurry of activity surrounding formally studying risk communication and set the stage for the contemporary understanding of risk communication (Davies, Covello et al. 1987; Krimsky and Plough 1987; Covello, McCallum et al. 1989; National Research Council 1989). The opening speech of the conference by William D. Ruckelshaus, former Administrator of the U.S. Environmental Protection Agency, reflects the change in attitude towards agency risk communication in the following statement (Davies, Covello et al. 1987, p. 7):

> My point here is not to say whether a sharing of the power to make risk management decisions is right or wrong; it is simply to state that it is a fact of life in the United States. We have decided, in an unprecedented way, that the decision-making responsibility involving risk issues must be shared with the American people and we are very unlikely to back away from that decision. So the question here before us is not whether there is going to be a sharing, whether we will have participatory democracy with regard to the management of risk, but how.

Two of the significant contributions to the risk communication field that came out of this time period were using communication theory to create effective risk messages and risk communication heuristics, both of which provided risk managers and others involved in the risk decision process with practical step-by-step risk communication techniques. Risk messaging techniques utilize communications theory, public relations theory, marketing theory and risk perception studies to create messages designed to inform and/or persuade message recipients (Krimsky and Plough 1987; Covello, McCallum et al. 1989; National Research Council 1989; Leiss 1996; Morgan, Fischoff et al. 2002). These techniques often focus on a mechanistic view of the risk messaging process that consists of a message source, message channel and message receiver (Krimsky and Plough 1987; Covello, McCallum et al. 1989; National Research Council 1989; Leiss 1996; Johnson 1999; Morgan, Fischoff et al. 2002). By breaking apart the risk messaging process, each element or "part" of the messaging "machine" may be separately diagnosed for effectiveness.

Following is a brief summary of the ideal risk messaging process as generally articulated under this view (Hance, Chess et al. 1988; Covello, McCallum et al. 1989; National Research Council 1989; Johnson 1999; Morgan, Fischoff et al. 2002):

- *Determine target audience*: After determining that a risk message is needed to inform or persuade, identify the target audience that will receive the message.
- *Determine audience perceptions*: Research audience demographics, and garner current perceptions of risk through focus groups or interviews.
- *Create a message*: Based on the audience analysis, create a message.
- *Pre-test message*: To ensure that the message will have its intended effect, pre-test it on a focus group, or at least have it previewed by other outside parties.
- *Select delivery channel(s)*: Based on the target audience analysis, specific channel medium(s) are selected and the message is tailored for that medium. Channel mediums could include but would not be limited to radio, television, community networks, direct mail, telephone, billboards, one-to-one communication, public hearings and press conferences.
- *Deliver the message*: Use the selected channels to deliver the message.
- *Evaluate message effectiveness*: After message delivery, gather feedback from the target audience and evaluate the message's impact.

In addition to the mid-1980s' risk messaging literature, risk communication heuristics that provided risk managers and others involved in the risk decision process with practical step-by-step risk communication methodologies became widely available. Many of these approaches are closely related to the risk messaging process advocated above; however, they also include general "rules of thumb." One good example is Covello and Allen's *Seven Cardinal Rules of Risk Communication* (Covello and Allen 1988). Their seven cardinal rules are:

1. Accept and involve the public as a legitimate partner.
2. Plan carefully and evaluate your efforts.
3. Listen to the public's concerns.
4. Be honest, frank, and open.
5. Coordinate and collaborate with other credible sources.

6. Meet the media's needs.
7. Speak clearly and with compassion.

Similarly, in *Improving Dialogue with Communities: A Risk Communication Manual for Government*, Hance, Chess, and Sandman (Hance, Chess et al. 1988) suggest very straightforward and detailed methods for every phase of implementing a two-way risk communication program, from earning trust and credibility through explaining quantitative risk estimates. Although all of the specific recommendations are too numerous to cover in detail here, a number of examples have been included to illustrate the manual's nature and intent:

- "Be forthcoming with information…."
- "Follow up…."
- "Avoid secret meetings…."
- "Don't remain silent…."
- "Involve the community at the earliest possible stage…."
- "Deal with everyone equally and fairly…."
- "Acknowledge people's feelings…."
- "Make sure that the people sent out to meetings are appropriate for the situation…."
- "Give people's concerns as much emphasis as the numbers…."
- "Avoid [risk] comparisons that seem to minimize or trivialize the risk…."
- "Acknowledge uncertainty…."
- "Use as down-to-earth language as possible…."
- "Always have question and answer periods after presentations." (pp. 4-83)

While acknowledging their recommendations' apparent simplicity and "common sense," the authors note that in agency practice, many of these recommendations are not implemented (Hance, Chess et al. 1988, p. 4). However, these step-by-step approaches, which continue to be refined through the present (e.g., U.S. Environmental Protection Agency 2003a; 2003b), marked formally acknowledging the importance of risk communication in the risk decision process.

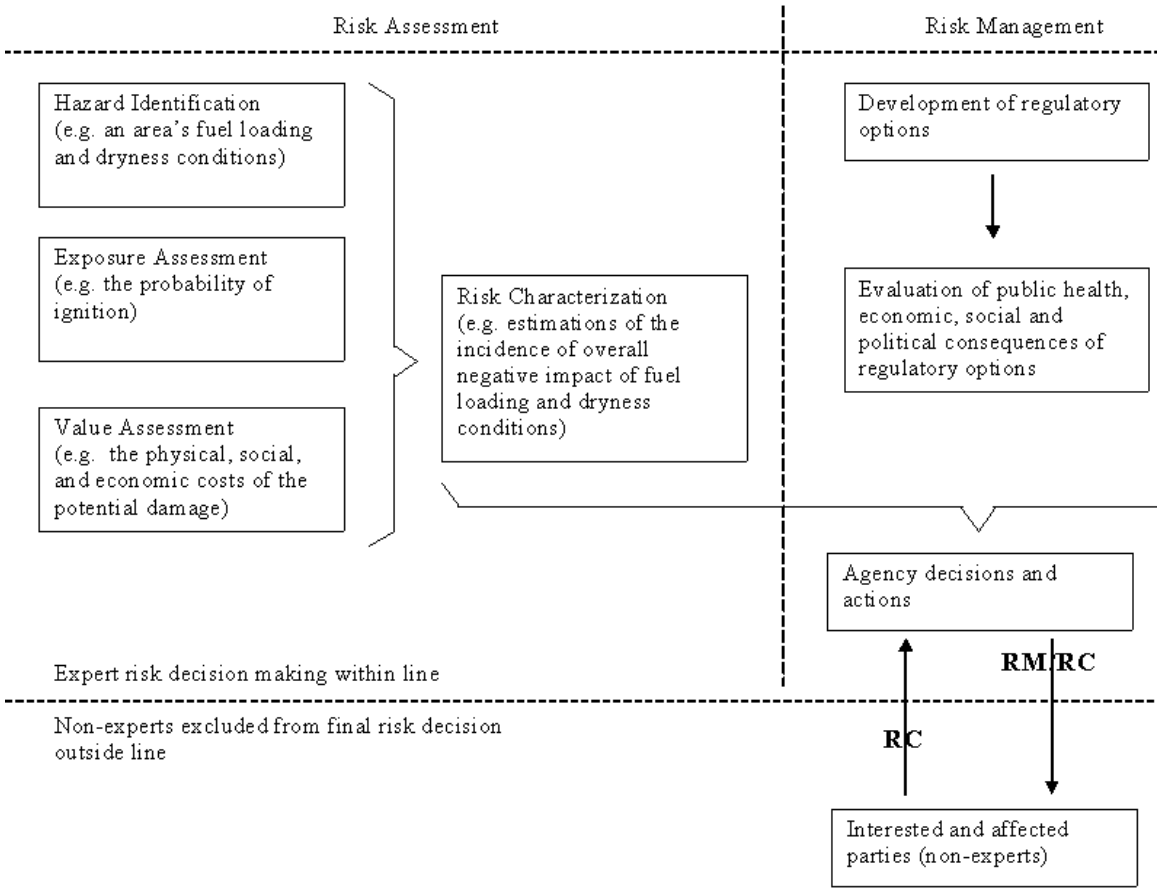
Stage II Risk Communication and the Risk Decision Process

Unlike Stage I, where risk is communicated only after the risk decision is made, Stage II incorporates interested and affected party feedback into three key areas:

- the risk assessment process, to aid primarily in identifying hazards;
- the risk management process, to aid in selecting regulatory options and evaluating political and social realities; and
- the communication of the risk decision itself, to ensure that risk messages regarding risk decisions are not only received by affected and interested parties, but that they are understood.

While Stage II practitioners may involve non-experts substantively for the first time in the risk decision process, the final risk characterization, the types of risk messaging used and the final risk decision are always the responsibility of the agency (see Hance, Chess et al. 1988; National Research Council 1989). This agency responsibility is, again, primarily a function of the underlying risk decision process. The process's underlying philosophy is that the objective science of risk assessment should still be separated not only from the subjectivity of risk management, but the subjectivity of the value judgments made by interested and affected parties. Figure 3 contains the graphical representation of Stage II risk communication embedded within a classic representation of the traditional risk decision process.

Figure 3 Stage II – Two-Way Risk Communication, and the Traditional Risk Decision Process*


Risk Assessment
Risk Management
Hazard Identification (e.g. an area's fuel loading and dryness conditions)
Exposure Assessment (e.g. the probability of ignition)
Value Assessment (e.g. the physical, social, and economic costs of the potential damage)
Risk Characterization (e.g. estimations of the incidence of overall negative impact of fuel loading and dryness conditions)
Development of regulatory options
Evaluation of public health, economic, social and political consequences of regulatory options
Agency decisions and actions
RM/RC
RC
Interested and affected parties (non-experts)
Expert risk decision making within line
Non-experts excluded from final risk decision outside line

*Risk decision model adapted from National Research Council (1983): *Risk Assessment in the Federal Government: Managing the Process, p. 21.* Risk communication depicted in this process is solely the responsibility of the author.

Note. RC = Risk Communication. RM = Risk Messaging.

Stage II Strengths

- *Recognizing risk communication as a critical part of the risk decision process*: One of the primary strengths for an agency in Stage II of conceptualizing risk communication is that there is an explicit acknowledgement that risk communication should be an integral part of the risk decision process.

- *Formalized risk messaging techniques and risk communication heuristics*: Once risk communication becomes recognized as a legitimate part of the risk decision process, there are many risk messaging and risk communication resources available to help practitioners increase their ability to risk message and implement basic risk communication processes effectively.
    - Risk messaging techniques allow agencies to not only deliver messages about risk, but to understand if they were received and understood by the target audience.
    - Risk communication heuristics provide risk communicators with basic tools to implement risk communication best practices. One rule of thumb, "be frank, open and honest" (Covello and Allen 1988) has been suggested to be a factor that may increase public trust in and credibility of government agencies (Peters, Covello et al. 1997).
- *Involving the public*: Stage II risk communication theorists and practitioners explicitly acknowledge that the public has a legitimate role in the risk decision process. Ruckelshaus' observation that the American democratic system demands that the public be involved in risk decisions affecting their lives is at least partially met in Stage II.

Stage II Weaknesses

- *Inability to deal with problems characterized by a low level of agreement on values and a high degree of scientific uncertainty regarding decisions' outcomes*. Such problems are referred to as wicked problems. We discuss their properties and the contexts in which they arise in Chapter 3.

  Unfortunately for risk communication practitioners, the expectations for risk communication when dealing with complex and multifaceted risk decisions are often too high (National Research Council 1989). Instead of expecting risk communication practice to "always reduce conflict and smooth risk management," the NRC (1989, p. 73) concludes that the goal of risk communication should be to "only ensure that the decisions are informed by the best available knowledge." However, when dealing with a wicked problem even this goal becomes difficult to accomplish: by definition, no amount of scientific or analytical effort will provide enough information to address, with sufficient certainty, all the critical ecological, social and political aspects of the risk decision. Therefore, when faced with a wicked problem, an agency can never be certain that its risk communication process meets even the modest goal of informing all stakeholders of all information that they consider to be the best available for making an adequate decision about risk.

  We suggest that the most productive approach for dealing with wicked problems is to seek broadly satisfactory, rather than optimal, solutions. A "satisfactory" solution in this context implies one that is consistent with ecological and legal constraints and is also acceptable to the public. We have characterized this approach as "collective satisficing." To encourage this collective satisficing, the

risk decision process must be reengineered into a deliberative, analytical and participatory risk decision process. When addressing wicked problems then, risk communication must be understood to be a part of that participatory process. However, this is the type of participatory decision making that is explicitly excluded in Stage II risk communication.

While the public is involved to the extent necessary to inform the risk decision experts in Stage II, they are not part of a participatory process. The traditional risk decision process ensures that the final risk decision is made exclusively by the agency. Risk assessors use public feedback to identify hazards, while risk managers use public feedback to help determine social and political options. However, the public is just another source of information to be considered in what is ultimately an agency decision. This may be effective for many routine risk decisions (National Research Council 1989; 1996), however, when dealing with wicked problems this approach is often not adequate to maintain trust and credibility in the risk decision process. For example, Slovic (1993) suggests that one of the only ways to substantially increase a community's trust of one type of wicked problem— locating a large nuclear power plant—would be to give a citizen advisory board the legal authority to shut it down if it felt that was necessary.

- *Lack of agency responsiveness*: Interested and affected parties who participated in two-way activities may lose trust in the process because the ultimate risk decision is left to the agency (National Research Council 1989; Chess, Salome et al. 1995a). For example, interested and affected parties who use extensive resources to help determine inference, social, and political options in the risk decision may become distrustful of the agency if, after this process, the agency releases a decision that misrepresents or excludes their views.
- *Failure to implement effectively*: Although risk communication heuristics and risk messaging steps may seem obvious, they are often neglected in practice (Covello and Allen 1988; Hance, Chess et al. 1988; Covello, McCallum et al. 1989; National Research Council 1989; Chess, Salome et al. 1995a; Morgan, Fischoff et al. 2002).
- *Access to the process*: The agency is solely responsible to determine and verify that all interested and affected parties are actually involved in the risk communication process. Given the wide variety of demographic and socioeconomic diversity involved in any given issue, ensuring that all interested and affected parties are involved may be extraordinarily difficult (National Research Council 1989; Vaughan 1995). There are few solutions for this problem in the literature, except to acknowledge that the potential for exclusion must be acknowledged (Vaughan 1995).
- *Risk messaging ethics*: Using the risk messaging approach discussed before, very effective risk messages can be designed to inform and persuade. Ethically, the question becomes: "Who can ensure that the persuasion is used to benefit and not to harm the individuals who are persuaded?" For example, Arvai (2003) suggests that indicating that a risk decision was arrived at through a participatory process has a strong positive impact on perception of the risk decision process. However,

> he also notes that this information could be used to influence interested and affected parties even when the participatory process was "superficial" or "non-existent" (p. 288).

Stage III: Participatory Risk Communication

In Stage III, participatory risk communication, the goals are similar to Stage II: comply with legal requirements, ensure understanding of agency risk communications through two-way interactive processes, and actively involve interested and affected parties in risk decisions that affect their lives. However, in Stage III there is a paradigm shift from a focus on expert/non-expert communications to a focus on broad-based deliberation and communication among all affected and interested parties: experts and non-experts are viewed as equal partners. This paradigm shift does not just impact risk communication, but also the entire risk decision process. Stage III risk communication relies on a risk decision process that emphasizes integrating risk assessment and risk management, acknowledging that analysis and deliberation are often equally important in complex and controversial risk decision processes. In this stage, there is the explicit acknowledgement that experts operating within the confines of a positivist risk decision process may not have all of the necessary answers to a complex risk decision, regardless of the amount of public feedback received in that process. Risk communication in Stage III then, like the risk decision process itself, is a tightly integrated analytical-deliberative process. Thus Stage III risk communication process leverages the risk messaging and risk communication heuristics developed in Stage II in the context of a participatory risk decision process.

Definitions

In Stage III, the specific definitions of risk communication and risk messaging may be considered the same as in Stage II. The key difference is the participatory risk decision context in which these definitions are utilized. It is still helpful then, to conceptualize risk communication in Stage III as, again (National Research Council 1989, p. 21),

> an interactive process of exchange of information and opinion among individuals, groups, and institutions. It involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management.

And risk messaging may still be conceptualized as:

> a written, verbal, or visual statement containing information about risk; may or may not include advice about risk reduction behavior; a formal risk message is a structured written, audio, or visual package developed with the express purpose of presenting information about risk. (p. 322)

History

William Ruckelshaus was more prescient than many realized in 1986 when he noted that risk managers in America would have to decide how to effectively incorporate participatory democracy into risk decision processes. Despite the Stage II improvements in risk communication that began in the mid-1980s, public distrust and skepticism of agency risk decision and risk communication processes was still prevalent, if not a worsening condition by the mid-1990s (see National Research Council 1989, 1996; Slovic 1993; Leiss 1996; Peters, Covello et al. 1997). In an effort to address this reality, what we characterize as Stage III or participatory risk communication began to develop.

Slovic (1993, p. 680) was one of the first to suggest that to restore trust, risk decision processes "may require a degree of openness and involvement with the public that goes far beyond public relations and *'two-way communication'* to encompass levels of power sharing and public participation in decision making that have rarely been attempted" (emphasis added). Fischhoff (1995, p. 142) suggested that the final stage of risk communication is acknowledging that "all we have to do is make them partners." Similar sentiments were expressed across the risk communication field, as suggested by a survey of risk communication practitioners and academics that indicated both were very interested in developing better ways to more effectively involve "outside interests" in the risk decision and risk communication process (Chess, Salome et al. 1995a, p. 116). Although this survey appears to indicate wide agreement across the field that participatory risk communication research is needed, no dominant theoretical paradigms have emerged specifically in the risk communication literature since the mid-'90s to provide specific guidance in this area. Much of the research has instead been devoted to improving the understanding of risk perception (e.g., Fisher and Chen 1996; Neuwirth, Dunwoody et al. 2000; Arvai 2003; Hamilton 2003) and refining risk messaging techniques for diverse target audiences (e.g., Vaughan 1995; Connelly and Knuth 1998; Morgan, Fischoff et al. 2002).

Stage III Risk Communication and the Risk Decision Process

One reason for this lack of theoretical development of participatory risk communication in Stage III is that the field lacks consensus surrounding its definitions, its indications for practice, or a widely agreed upon theoretical framework. For example, participatory risk communication is considered by some to be nearly synonymous with what we have characterized as two-way communication practices (e.g., Bostrom and Löfstedt 2003). As we have attempted to show, however, two-way risk communication practices are linked to a risk decision process that not only separates risk assessment and risk management, but also separates interested and affected parties from the final risk decision. This two-way communication process has been shown in practice to fall short as a tool to inform and/or persuade in order to contribute to resolving complex risk decisions—as indicated by widespread agreement on the growing lack of trust of agency risk decisions. We suggest that it must be explicitly acknowledged that the only way for truly participatory risk communication to occur is within the context of a participatory

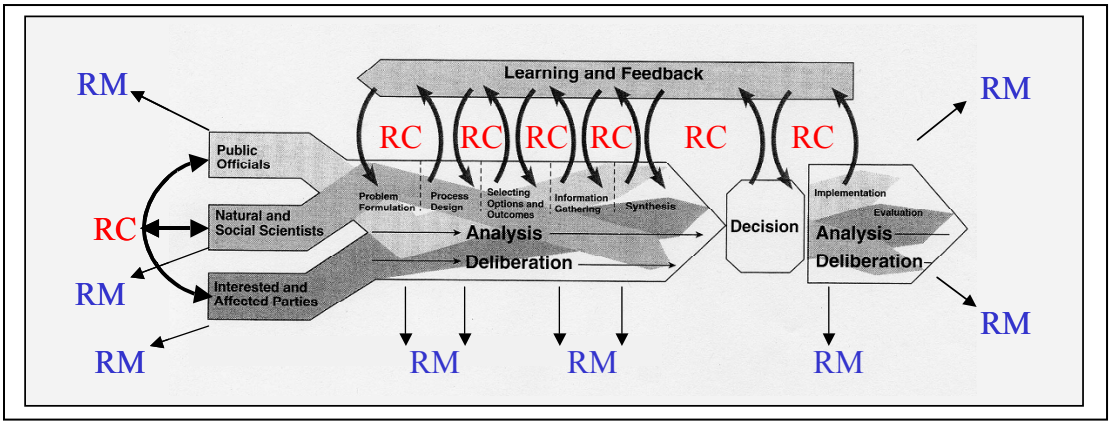
risk decision process that largely integrates the risk assessment and risk management functions.

One recent volume that details participatory risk decision processes is the National Research Council's *Understanding Risk: Informing Decisions in a Democratic Society* (1996). Although focusing primarily on the risk characterization process, the book provides a useful conceptual framework of participatory risk decision processes, of which our Stage III's understanding risk communication and risk messaging are integral parts. Within the context of a participatory risk decision process, the effectiveness of risk communication and risk messages rely on the decision process's participatory nature. The 1996 NRC report (1996, p. 37) states,

> a risk characterization is part of a process that begins with the formulation of a problem… and ends with a decision. A risk characterization cannot make up for deficiencies in other parts of the process; inversely, if the other parts of the process are done well, it is far more likely that the risk characterization will be both clear and useful.

The same could be said for risk communication and risk messaging using this model: risk communication among actors in a process that does not representatively include all interested and affected parties will very likely be deficient in producing the desired results of informing or persuading. Figure 4, originally from NRC (1996, p. 21), has been modified to show risk communication and risk messaging elements as part of this process.

Figure 4. Risk Communication (RC) and Risk Messaging (RM) in a Participatory Risk Decision Process.



While Figure 4 still shows risk messages as "one-way written, verbal, or visual statements containing information about risk," and risk communication as an "interactive process of exchanging information and opinion among individuals, groups, and institutions," it is a participatory process that determines the message source, message channel and message receiver for risk messages, and defines the context for communications about risk among all interested and affected parties.

Strengths

- *One possible risk communication solution when addressing wicked problems*: As stated above, we have suggested that the most productive approach for dealing with wicked problems is to seek broadly satisfactory, rather than optimal solutions that "collectively satisfice." To encourage this collective satisficing the risk decision process must be reengineered into a deliberative, analytical and participatory risk decision process. Stage III risk communication, as part of such an analytical deliberative process, may be the only workable risk communication solution for wicked problems.
- *May be the only way to increase trust*: Slovic (1993) suggests that in an environment where distrust of government institutions is common, participatory risk management processes may be the only practical solution. The regression models created by Peters, Covello et al. (1997) suggest that overall individual perceptions of trust and credibility of government agency risk messaging are based on the agency's perceived commitment, openness and honesty, knowledge and expertise, and concern and care—all traits that are enhanced through participatory risk decision processes.
- *May increase acceptance of controversial risk decisions*: Arvai's (2003) recent study suggests that post-decision risk messaging that includes describing a participatory risk decision used to make the decision increases public support. In addition, Arvai's conclusions suggest that it may be the case that individuals who did not participate in the risk decision process and who *did not agree with the decision outcome* may be more likely to accept the risk decision's validity if they were shown that the decision was based on a public participation process.
- *Risk messaging ethics are addressed by the participatory process*: While the intent of risk messages may still be to inform and persuade, a participatory process involving all interested and affected parties is a safeguard against risk messages used in a way that is disingenuous or ultimately harmful to recipients. While the format and most effective delivery of the message is of course left to a professional risk communicator, the message's content and goals are determined through a participatory process.

Weaknesses

- *Inefficiency*: Even strong proponents of participatory risk decision processes and the corresponding risk communication activities acknowledge the difficulties in implementing a truly participatory risk decision process. Chief among these concerns are the following (National Research Council 1996, p. 134; Beierle and Cayford 2002, p. 27):
    - *Cost*: The agency incurs costs in providing the resources and commitment to creating a truly participatory risk decision process.
    - *Delay*: Increasing the number of participants in all stages of the risk decision process will almost inevitably lengthen the risk decision process.
    - *Confusion*: By bringing non-expert citizens into the risk assessment and risk management process, there is a large opportunity for confusion,

particularly surrounding technical analyses, risk quantification methods, and the surrounding uncertainties.

- *Stakeholder selection is still an issue*: As stated above, determining and verifying that all interested and affected parties are actually involved in a risk decision and hence risk communication process is difficult, particularly given the wide variety of ethnic and socioeconomic diversity in any given issue (Vaughan 1995).
- *Implementation uncertainty*: There is not a rich body of literature on creating a participatory risk communication process: most is limited to advocating a two-way communicative process that falls short of encouraging full democratic participation in all aspects of the risk communication process.

Risk Communication in the SNFPA

The Sierra Nevada Forest Plan Amendment (SNFPA) process included a number of events that illustrate the Forest Service's characterizations of risk communication. As the history and chronology of this process are provided in Chapter 4, here we simply highlight how risk communication by the USDA Forest Service's Pacific Southwest Region has evolved over a 10-year period.

In response to growing concern with the decline in California spotted owl populations, a technical assessment was commissioned to ascertain the effectiveness of Forest Service policy in protecting spotted owl habitat. This risk assessment activity, performed by technical experts, concluded that Forest Service policy was insufficient to adequately protect spotted owl habitat; in addition, they recommended a short-term strategy of aggressive thinning to protect California spotted owl habitat from the potential of catastrophic wildfire. The Forest Service implemented the assessment team's recommendations through preparing an Environmental Assessment and a Finding of No Significant Impact (FONSI) decision issued in January 1993.

Through the release of the FONSI in January 1993, the Forest Service risk communication process surrounding events related to the SNFPA could be best characterized as a Stage I, one-way risk communication. The risk assessment report, performed by experts without the input of other interested and affected parties, provided the Forest Service with options to protect the California spotted owl. Although the report was released to the public in 1992, opportunities for interested and affected party feedback were not part of the process. The Forest Service risk communication activity involved releasing the technical report and announcing the risk decision implementing the assessment team's recommendations.

As the literature on risk communication has evolved through Leiss's (1996) three phases or Fischhoff's (1995) eight stages, so have the Forest Service's risk communication practices. In May 1993, the Forest Service began to work on an Environmental Impact Statement and a draft statement was released in 1995. This Draft Environmental Impact Statement met with considerable controversy, and new information was identified during the comment period. In a classic instance of Stage II risk communication, feedback

obtained during this comment period was taken into consideration as this DEIS underwent thorough review and revision.

Sustained participation from stakeholders such as the Quincy Library Group has led the Forest Service to consider proposals generated outside the agency. So in some sense, they have gone beyond Stage II of the risk communication process by making external stakeholders participants in the process of generating implementable alternatives.

Since 1998, the Forest Service has moved aggressively to inform the public and to solicit information from a variety of sources. In particular, the Record of Decision and Final Supplemental Environmental Impact Statement (USDA Forest Service 2004b, pp. 1-10) states in its chapter on public participation that

> The Sierra Nevada Framework for Conservation and Collaboration has been dedicated to building and improving relationships with Indian tribes, other agencies, local governments, and the public. Improved working relationships provide for mutual learning and understanding, and result in well-reasoned recommendations for public policy.

Over the last 10 years, then, the Pacific Southwest Region has kept abreast of the latest recommendations on risk communications as it has attempted to involve the public in its risk assessment and risk management activities.

SUMMARY

After a brief introduction to the social science disciplinary perspectives on uncertainty and risk, we have devoted the bulk of this chapter to discussing risk communication. The different perspectives on uncertainty and risk help inform public agencies' understanding of the risk and uncertainty dilemmas they face. However, there is little that an organization can do about the sources of risk. What public agencies can do is communicate effectively with agency and external stakeholders about these risks, and collaborate on an approach to learning about them in order to address them.

The risk communication strategies undertaken by the Forest Service in the Sierra Nevada Forest Plan would fall into what we describe as Stage II of the risk communication strategies. They have attempted to move toward Stage III strategies, but are organizationally and legally constrained from making interested and affected stakeholders full partners in the decision-making process.

It is becoming increasingly clear from the academic literature, as well as from the experience of public agencies such as the Forest Service, that current procedures to deal with complex problems are not working. Part of the inability to address such problems arises from the multiple and diverse sources of risk and the lack of consensus on how to address these risks. In Chapter 3, we elaborate upon the nature of these wicked problems and why they cannot be solved. There is, however, some hope that although we may not be able to solve these problems, we can manage them through a collaborative and enhanced adaptive management process.

CHAPTER 3. THE NATURE OF WICKED PROBLEMS

INTRODUCTION

Many of society's pressing problems—in environmental management and elsewhere—are characterized by high levels of complexity and social conflict, and profound social and cultural values come into play. In these most complex cases, the processes of defining shared values, common goals, desirable outcomes, and acceptable risks become political. Consequently, technical analyses alone—which do not integrate social values and deliberation—cannot provide an adequate decision-making support framework. In other words, when scientific uncertainty coexists with value uncertainty and conflict, we have "wicked problems."

To better understand the history and nature of this class of problem, this chapter discusses the term "wicked problem" as it first appeared in the systems and planning literature. We then discuss the nature and source of public policy problems classified as wicked problems to set the stage for discussing the Sierra Nevada National Forests of California's management situation as a wicked problem in Chapter 4, and approaches to dealing with wicked problems in subsequent chapters. Finally, of numerous social and environmental problems that fall into the category of wicked problems, we discuss two that are both large-scale and highly representative for the public natural resource arena: the Northwest Forest Plan, a case where an authoritative strategy combined with the precautionary principle and adaptive management has failed to produce the intended results; and the Interior Columbia Basin Management Plan, where a competitive strategy and significant investment in both scientific assessment and planning failed to reach a conclusion. Chapter 4 will make the case for the Sierra Nevada Forest Plan Amendment process as a wicked problem.

DEFINING "WICKED PROBLEM"

Decision making in the public arena occurs at various levels of complexity. This complexity takes many forms, including high levels of risk and/or scientific uncertainty, biological and/or social complexity, scope and scale of the issues involved, and absence of a clear public consensus on values, the nature of the problem, and/or acceptable solutions. Increasingly complex biological, social and economic models can help the decision maker understand the nature of these types of decision problems.

Clearly, some public problems are more difficult to resolve than others. Renn (1995) suggests that environmental debates operate on three levels, and that ecological risk assessment has *decreasing utility* as an input into policymaking as levels of complexity and conflict increase. For straightforward problems, scientific analysis can serve as a basis for policy making with little controversy. At a medium level of complexity, public trust in the implementing institutions and their technical expertise is required. It is at the

highest level of complexity and conflict that political forces overshadow technical analyses, making stakeholder involvement absolutely essential.

Consider two dimensions of any decision: the state of knowledge necessary to make the decisions, and the level of agreement on guiding values (Table 2, adapted from Committee of Scientists 1999, p. 131). Given these decision environment characteristics, there are four possible scenarios. If the knowledge base underpinning an issue is well understood and generally accepted, and stakeholder agreement on values is high, then decision making is easy and stakeholders may be comfortable with an agency-expert or authoritative strategy.

Table 2. Issues and Wicked Problems

	Agreement on Values	
State of Knowledge	**High**	**Low**
Well Developed	Routine analysis with periodic stakeholder and expert review. *Decisions are Easy*	Emphasis on stakeholder deliberation with periodic expert review.
Tentative/Gaps/ Disagreements/ Research Needed	Emphasis on expert deliberation with periodic stakeholder review.	Emphasis on both stakeholder and expert deliberation. *Wicked Problems!*

If agreement on values is low, but the science is well understood, then focus is on dialogue among the stakeholders, guided by the science, to try to understand and resolve value differences. When the science is uncertain and there are important gaps in the knowledge base, but stakeholder agreement on values is high, then focus is on resolving the science issues with oversight and engagement by the stakeholders (when needed) to assure that their values are being reflected in the science and decision making. But when both the science is uncertain and agreement on values is low, then the issue becomes a wicked problem, and significant dialogue among scientists, stakeholders, and decision makers is needed.

Raiffa (1968) defines a decision problem as a choice among a set of acts $A_i, \ldots, A_m$; that A_i which optimizes the decision maker's return U_{ij}, where U_{ij}, is the utility or value to the decision maker of the outcome O_{ij} corresponding to the doublet (A_i, S_j) where is the set of the "states of nature." When the relationship between A_i and O_{ij} is unambiguous, we have programmed decisions (Simon 1960, p. 5) which fall into the top left-hand quadrant of Table 2. Problems belong to the top right-hand quadrant when there is uncertainty about values, and consequently U_{ij} is unclear. Problems in such contexts are generally addressed through political means, and solutions are arrived at through debate and compromise. On the other hand, when values are clear and U_{ij} are known with certainty, but when outcome O_{ij} corresponding to the doublet (A_i, S_j) is not known with certainty, additional information is needed. This class of problems in which there is doubt regarding an action's consequences belongs in the bottom left-hand quadrant. An unprogrammed decision (Simon 1960, p. 5) or wicked problem (Churchman 1967; Rittel and Webber 1973) is one for which "one or more of the $\{A_i\}$,

$\{S_j\}$, $\{O_j\}$ or $\{U_{ij}\}$ terms or sets is totally unknown or not known with any high degree of 'confidence'" (Mason and Mitroff 1973, p. 479). For such ill-behaved problems,

> if the idea of the solution is elaborated or even changed during the design process, new aspects become relevant and new kinds of information will lead to different questions about what is the case in the particular situation and about what is desired or acceptable. Since nobody can anticipate all conceivable design possibilities before design starts, nobody can list all potentially relevant data in a complete, well-defining problem formulation (Rittel 1971, p. 19).

Thus, in the absence of a precise problem formulation, managers need to develop, according to Vickers (1965, p. 40), an "appreciation" of the problem by which they reach "judgements of fact about the 'state of the system' both internally and in its external relations" and "judgements about the significance of these facts to the appreciator or to the body for whom the appreciation is made." For Wildavsky (1979) this appreciation, which eventually leads not to a solution, but some resolution or settlement, requires "a smart mix of cogitation and interaction" (Grin and Hoppe 2000, p. 180). Conklin and Weil (1997) suggest that a characteristic of wicked problem appreciation is that "you don't understand the problem until you have developed a solution." Thus, despite increasing experience with such problems, the definition of wicked problems remains largely unchanged after almost 40 years.

WICKED PUBLIC POLICY PROBLEMS

Wicked problems, by their very nature, are difficult to generalize. However, they seem to have a number of common characteristics, especially when compared with more normal decision problems. For example, Conklin (in press) characterizes "tame" problems as those that:

- have a well-defined and stable problem statement,
- have a definite stopping point (one knows when a solution is reached),
- have a solution that can be objectively evaluated as either right or wrong,
- belong to a class of similar problems which are solved in a similar way,
- have solutions that can be easily tried and abandoned if they don't work, and
- come with a limited set of alternative solutions.

In sharp contrast, some of the key characteristics of wicked problems as defined for public land management are (Allen and Gould 1986):

- The definition of the problem is in the "eye of the beholder"; that is, each stakeholder defines the problem differently and therefore there is no single correct formulation of the problem.
- Outcomes are not scientifically predictable.
- The decision maker cannot know when all feasible and desirable solutions have been explored.
- The resources of ecosystems, communities of interest, funds, organizational capabilities, etc., combine with stakeholder demands in idiosyncratic ways; therefore, any solution is likely to be "one-shot" and unique.
- Solutions are generally better or worse, rather than true or false.

These characteristics result in some disturbing outcomes. For example, Rittel and Webber (Rittel and Webber 1973) identified ten distinguishing properties and outcomes of wicked problems.

1. *There is no definitive formulation of a wicked problem*. "The formulation of a wicked problem *is* the problem!" In a wicked problem, every question asking for additional information depends upon the understanding of the problem, and its resolution, at that time. Problem understanding and resolution are concomitant. Therefore, in order to adequately describe a wicked problem, one has to develop an extensive inventory of all conceivable solutions ahead of time.
2. *Wicked problems have no stopping rule*. There are no criteria that tell when *the* solution or *a* solution has been found in dealing with wicked problems. Because (a) the process of solving the problem is identical with the process of understanding its nature, (b) there are no criteria for sufficient understanding, and (c) there are no ends to the causal chains that link interacting open systems, the manager/planner can always invest more efforts to increase the chances of finding a better solution. The manager therefore terminates working on a wicked problem for considerations external to the problem: he or she may run out of time, money, or patience, rather than having solved the problem.
3. *Solutions to wicked problems are not "true or false," but "good or bad" or "better or worse" or "satisfying or good enough."* In a wicked problem, the parties involved are equally equipped, interested, and/or entitled to judge the solutions, although none has the power to set formal decision rules to determine correctness. Their judgments are likely to differ widely in accordance with their community or personal interests and values.
4. *There is no immediate and no ultimate test of a solution to a wicked problem.* With tame problems, one can immediately determine how good a solution has been. With wicked problems, on the other hand, any solution implemented will generate waves of consequences over an extended period of time. Additionally, there is no way of tracing all the waves through all the affected lives within a limited time schedule, and ahead of time, since the full consequences cannot be appraised until the waves of repercussions have completely run out—which may, in the case of issues involving forest ecosystems, take decades or even centuries.
5. *In a wicked problem, there is no opportunity to learn by trial and error. Every solution is a "one-shot operation."* Every implemented solution is consequential. Its consequences are generally irreversible and they generate long half-lives. So every trial counts! And every attempt to correct a decision and its undesired outcomes poses another wicked problem dilemma.
6. *Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.* In the case of wicked problems, there are no criteria that enable someone to prove that all solutions have been considered. With these ill-defined problems and solutions, the set of feasible plans of action relies on realistic judgment and on the amount of trust and credibility between policy makers and the public, which may be small or nonexistent.

7. *Every wicked problem is essentially unique.* There are no rules or solution principles that can be developed to fit all members of a class of wicked problems. In the complex world of social policy planning, every situation is one-of-a-kind.
8. *Every wicked problem can be considered to be a symptom of another problem.* Problems can be described as discrepancies between the state of affairs as it is and the state as it ought to be. The process of resolving the problem starts with searching for causal explanation of the discrepancy. Removing that cause poses another problem of which the original problem is a "symptom." In turn, this newly formulated problem can be considered the symptom of still another "higher level" problem, e.g., street crime can be considered a symptom of poverty.
9. *The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution.* When dealing with wicked problems, there are several ways of refuting a hypothesis. Because of the problem's uniqueness, and lacking opportunity for rigorous experimentation, the modes of reasoning used in the argument in dealing with wicked problems are much richer than those permissible in scientific discourse. The choice of explanation is arbitrary, and attitudinal criteria guide the analyst's choice. Everyone will pick the solution that conforms to the action-prospects that are available to him or her.
10. *The planner has no right to be wrong.* In science, solutions to problems are considered hypotheses that are offered for refutation. And, the scientific community does not blame its members for postulating hypotheses that are later refuted. In dealing with policy issues as they relate to wicked problems, however, planners are liable for their actions' (or inactions') consequences. Here, the aim is to find ways to improve some characteristics of our world; thus a policies' effects can matter a great deal to people touched by the actions taken.

A significant component of wicked problems is social complexity. Conklin (in press, p. 1) describes the social complexity of wicked problems as consisting of a number and diversity of stakeholders who are part of the problem-solving process: "Social complexity means that the environment of a project team is populated by individuals, other project teams, and other organizations who have the power to undermine the project if their stake is not considered…" He further states that the main barrier to collaboration in solving problems is fragmentation caused by wicked problems and social and technical complexity. He defines fragmentation as the situation where stakeholders "are all convinced that their vision of the problem is correct. Stakeholders can be fragmented in both their interests and the tactics that they use to pursue those interests" (Salwasser 2002). The way to combat fragmentation is through "shared understanding and shared commitment, which is inherently a social process" (Conklin in press, p. 1). Conklin continues that managers and decision makers typically fail to recognize that they are dealing with wicked problems. This leads to thinking, tools and methods that are useful only for simpler "tame" problems.

Most, but not all, large-scale planning issues involving publicly owned natural resources have become controversial. Public values about the role of public lands in meeting natural resource supplies, rural community demographic changes, and concerns about

declining populations of certain plants and animals, combine with issues of scientific uncertainty and geographic scale to create wicked problems. Salwasser (2002) addressed the nature of natural resource problems in today's decision environment. He characterized them by

- *their complexity and messiness*: no definitive problem statement, and multiple problems with multiple objectives,
- *the existence of fragmented stakeholders*: both in interests and in tactics used to pursue their interests,
- *scientific messiness*: multiple factors influence each problem area or objective, and the manager can only influence some of these factors,
- *uncertainty*: two kinds of uncertainty: (1) we do not know but can eventually learn, and (2) we can not know until it occurs. To this we add a third: we do not know that we do not know,
- *conflicting risks*: there are conflicting risks between objectives and between short-term and long-term objectives, and
- *dynamic social, economic, knowledge, and technological systems*.

Thus, wicked problems are extremely complex and not easily solved. However, and perhaps because of their complexity and seeming intractability, there is a growing body of literature and practical experience contributing to understanding and, hopefully, "taming" such problems.

COPING STRATEGIES

There seem to be few examples of complete success in dealing with wicked problems. In an almost tongue-in-cheek manner, Conklin (in press) suggests six ways to tame wicked problems:

1. Lock down problem definition by defining a related or subproblem that can be solved.
2. Because wicked problems have no definitive solution, declare the problem solved without clarifying what the problem was, of course, after defining the problem as in 1.
3. Develop objective parameters by which you can measure the solution's success.
4. Recast the problem as being just like a previous problem that has been solved, and ignore any evidence that complicates the issue.
5. Give up on trying to solve the problem, just do your job and stay out of trouble, hoping that someone else may solve it.
6. Pretend that there really are just a few possible solutions and then focus on selecting from among them.

The problem with any of these "solutions" is that while they may work in the short term, over the longer term, the problem will only reassert itself. If problems are to be solved, messes (wicked problems) may have to be endured. This leads decision makers and stakeholders into a number of coping strategies.

Roberts (2000) describes three alternative coping strategies for dealing with wicked problems: *authoritative*, *competitive* and *collaborative.*

Authoritative Strategies

Authoritative strategies try to "tame" wicked problems by putting problem solving into the hands of a few stakeholders who have the authority to define the problem and solve it (Salwasser 2002). In a democracy, authoritative coping strategies work and are sustainable as long as all the stakeholders yield power and authority to the chosen few and agree to abide by their decisions. Reducing the number and diversity of stakeholders with authority to define and solve the problem decreases the problem's complexity. But the authorities can be wrong about the problem and wrong about the solution. Further, authoritative strategies may not do an adequate job of keeping the citizenry informed and engaged in the governing process. Even in a democracy, authoritative strategies are not very democratic. As discussed later in this chapter, authority was essentially the strategy employed by the Forest Ecosystem Management Assessment Team (FEMAT) and its several precursors after other more competitive and collaborative strategies had failed to yield a solution. Then it was used again in the political and legal modifications made to the option designed by the scientific experts in what became the Northwest Forest Plan. The first authoritarian exercise may have made the plan socially unacceptable to some stakeholders. The latter exercise made it impossible to implement.

Authoritative approaches can be quite efficient as long as power is tightly held or freely given (Salwasser 2002). The Forest Service has used this strategy very effectively in the past, and was able to tame wicked problems because it was given the authority to define the problem and make the solution. But, in today's environment, this is not the case.

Competitive Strategies

Competitive strategies are played out on the battlefield, in politics, or the market (Salwasser 2002). They assume a zero-sum game, and a win/lose attitude permeates the environment. Central to pursuing competitive strategies is the quest for power. And, as more power is acquired and held it can change the coping strategy from competitive to authoritative. Competition can be an efficient temporary solution strategy for wicked problems, but pushed to the extreme it can lead to violence and warfare. It can also lead to an intermediate gridlock situation as stakeholders have enough power to block one another, such as through judicial rulings or political means, but not enough power to actually achieve a solution or accomplish something. This characterizes the situation we find in many natural resource issues.

Competitive strategies can also yield workable solutions for a time if those who walk away from the process are kept in check, as now often happens through litigation or political power (Salwasser 2002). But little learning ever occurs when the participants resort to these strategies, so it is not a sustainable solution for wicked problems. For large-scale, complex problems, the decision process must "be immune from power plays by individuals or groups resorting to authoritative or competitive coping strategies" (Salwasser 2002).

Collaborative Strategies

Collaboration means working together by the multiple stakeholders who share power to jointly define "the problem(s)" and find acceptable and realistic solutions to the problem(s) (Roberts 2000; Salwasser 2002). It seeks win/win solutions, and shares both the costs and benefits of these solutions, as well as provides strength in numbers and organizational efficiencies. At the same time, there are increased transaction costs: adding more stakeholders, more meetings, more time, and the time and effort required to learn new interpersonal skills. It also requires compromise. As Salwasser (2002) notes, "Collaboration can work only if stakeholders agree to share power and see mutual reward in the outcome." Dialogue can break down and yield to hardened positions, with collaborators walking away from the process and resorting to competition or authority for solutions to their liking. Therefore, despite the major time commitment to make collaborative strategies work, there are no guarantees that collaboration will yield outcomes satisfactory to everyone.

To succeed, collaborators must agree to share power, and the process of collaboration must increase the likelihood that the various stakeholders will have equity in how their concerns and interests are addressed (Salwasser 2002). It must, therefore, increase the likelihood that critical and creative thinking will occur, and that the decision process will lead to higher "buy in" from those the decision affects. Collaboration cannot occur without full openness and mutual respect in how all aspects of the decision process are handled. Openness means full disclosure and honest and appropriate use and characterization of knowledge, uncertainties, risk and values. Mutual respect requires a commitment to stay within the process and not resort to power plays.

Collaboration on complex problems requires a willingness to compromise for the larger, collective good. And it requires a great deal of time, patience, and commitment. As complex planning processes move slowly, it is likely that there will be one or more changes in the key stakeholders and/or decision makers, which makes it difficult for individuals to make commitments to a process that may be sidetracked by changes in key people along the way (Shindler, Cheek et al. 1999).

It is in the individual coping strategies that wicked problems get defined, where objectives are set, where alternatives are framed, and where likely consequences are evaluated for how well they address the objectives and solve the problems. Science assists in these coping strategies reaching stakeholder goals, but can never drive them: these are social and political processes, not scientific issues. Therefore, natural resources' policy and plans are science-informed, not science-based. And they are always value-based. Therefore, to be truly successful in taming wicked problems, it will be necessary to develop the commitment and organizational and individual skills to use collaborative strategies.

TIME FRAMES AND GEOGRAPHIC SCALE

The sociopolitical and environmental systems involved in natural resource issues have both time and spatial dimensions. For instance, the regulations implementing the National Forest Management Act of 1976 require that the USDA Forest Service maintain viable species populations throughout their range when considering forest plans and individual projects. There is concern that individual plans made in a portion of a species' range do not cumulatively jeopardize the species' long-term viability as each separate individual plan is implemented. The cross- or multi-range nature of species (who do not adhere to man-made boundaries) has increasingly forced the agency to consider large geographic-scale planning efforts to prevent cumulative negative effects of incremental decision making. At the same time, the planning regulations require preparing and implementing forest plans by each local planning unit, generally the individual national forest. The Forest Service's philosophy, dating back to its first Chief Forester, Gifford Pinchot in 1905, is to delegate management responsibility to the local level, where the local community's needs and the resources' variability and land capability come together. Planning across distinct administrative units increases complexity and adds to the number of issues and problems that must be addressed in the planning process, including the number of stakeholders who must be engaged.

In addition to these scale issues, the long time frames of ecological response, and the short time frame of the sociopolitical process and changing societal values, result in added complexity. On the time scale, the sociopolitical environment can be rather volatile, changing with the next election or lawsuit. Planning is also limited in terms of human lifetimes and the difficulty of future, multigenerational projections. On the other hand, natural environments—especially forests—change continuously, but slowly, on the order of decades and even centuries. Experimentation to satisfy issues of uncertainty may take decades to resolve; in the meantime, the sociopolitical process may demand faster resolution or change in direction before we can know if the old direction was satisfactory. This is further complicated by the long time frame of a complex, large-scale planning process, in which the issues that initially framed the planning process could change before the decision is reached.

At the landscape scale, there are issues of local concern and issues of broad concern, especially with respect to species that have wide ranges. Further, all issues have both a stakeholder community of place (those most immediate to the affected area) and a stakeholder community of interest (a broader group that can live anywhere, and who, if disenfranchised, can resort to competitive strategies to assert their rights). Those interested in community-of-place issues can often find more ready agreement because they share a common interest in the local community and have to coexist after the debate ends and the decision is made. For these same reasons, it is much harder for the broader community of interest to make necessary compromises and move forward. It is also more difficult for the decision makers to identify potential distant stakeholders and to find ways to meaningfully engage them in the planning process. Yet, given the controversy over managing the nation's forests, there are not likely to be many issues that

are purely of local community interest. Perhaps new technology using the Internet and videoconferencing can be brought to bear in the future.

CASE STUDIES: WICKED PROBLEMS IN NATURAL RESOURCE DECISION MAKING

A fundamental concept in science is that all things are determined. That is, there is an explanation for all events and conditions in the form of a set of antecedent conditions, factors, or determinants that together determine or "cause" the event. This principle is called the principle of determinism (Bunge 1959). Any biological event involves at least two and often several major antecedents, called multiple determinism (Kimmins 2003). If the number of determinants is large, i.e. greater than 30, we have statistical determinism. The principle of determinism's importance is: the fewer the antecedents, the more predictable the event. As complexity of a condition or event's determinism increases, the predictabilty of the condition or event's occurrence decreases. In multiple determinism, an events' predictability may vary from low to high. In statisical determinism—rarely seen in biological events—the very large number of antecedents combine to produce seemingly random unpredictable event occurrences with very low predictability. Forests are complex biological and physical systems with a high degree of interaction and interdependence among the various parts. Because of their complexity, interaction and interdependence, most events and conditions in the forest are determined by many antecedents, i.e. they are multiply determined (Kimmins 2003).

Two recent wicked problems, the Northwest Forest Plan and the Interior Columbia Basin Plan, illustrate this point. Both are extremely large scale and the outcomes of the management actions on the affected ecosystems multiply determined, with the first arising from intervention by the President of the United States, and the second resulting in a long-term, expensive (> $40 million) planning effort that resulted in no final decision.

The Northwest Forest Plan (NWFP)

In the late 1980s a series of lawsuits brought in federal courts in the Pacific Northwest resulted in an injunction against logging all old-growth forests in the national forests and Bureau of Land Management Districts within the natural range of the northern spotted owl. Despite numerous efforts to revise the forest plan's direction using various teams of scientists and planners, and some intervention by members of Congress who requested that a scientific team headed by Dr. Jack Ward Thomas develop a set of alternatives, plaintiffs successfully argued that protections in place in existing national forest and Bureau District plans were inadequate to assure viability of the northern spotted owl, as required by regulations implementing in the National Forest Management Act (NFMA) of 1976. This precipitated a major economic crisis in the Pacific Northwest, where many communities were dependent upon timber supplies from local federal forests. Moreover, the crisis occurred during an election year. Presidential candidate William Clinton, in a campaign visit to the Pacific Northwest, made a promise that, if elected, he would convene a high-level "forest summit" to resolve the issue. Following his inauguration,

President Clinton held this summit in Portland, Oregon in May 1993. The summit included federal, state, and agency heads; local citizens and elected officials; and the president, vice president, and cabinet secretaries.

The Northwest Forest Plan was driven by the need to meet the requirements of the Endangered Species Act of 1973 (P.L. 86-517, 74 Stat. 215) and the "viability clause" of the USDA Forest Service's (FS) regulations issued pursuant to the National Forest Management Act of 1976 (P.L. 94-588, 90 Stat. 2949). An Executive Committee composed of ten department and agency heads of the affected federal agencies was established by President Clinton subsequent to the Forest Summit to oversee the planning effort. At the close of the Forest Summit, President Clinton named an interdisciplinary team including economists; social and political scientists; veterans of earlier efforts from the ranks of wildlife, fisheries, and conservation biologists; foresters; Geographic Information System specialists; cartographers; ecologists; botanists; entomologists; and other specialists. Chaired by Jack Ward Thomas, this team was called the Forest Ecosystem Management Assessment Team (FEMAT). FEMAT was given 60 days (later expanded to 90 days) to deliver management alternatives, with full assessments of each, to the president for his consideration. The Executive Committee quoted President Clinton's observations at the conclusion of the Forest Summit in providing FEMAT these directions (Forest Ecosystem Management Team 1993):

- Consider human and economic dimensions of the problem solution.
- Protect the long-term health of forests, wildlife, and waterways.
- Efforts should be scientifically sound, ecologically credible, and legally responsible.
- Produce a predictable and sustainable level of timber sales and non-timber resources that will not degrade the environment.
- Employ and emphasize collaboration in management as opposed to confrontation.

In addition, FEMAT (1993) was instructed to minimize impacts on non-federal land, make suggestions for adaptive management, examine silvicultural management to achieve objectives, use an ecosystem management approach, and apply the "viability standard" from the Forest Service's planning regulations of Bureau of Land Management (BLM) lands.

FEMAT (1993) delivered 10 options to the president, who selected Option 9. A multidisciplinary planning team was assembled to prepare the required Environmental Impact Statement and the Record of Decision (ROD). The result became known as the Northwest Forest Plan (NWFP) or the President's Forest Plan. Because the ROD was signed at the highest level in the administration, there were no appeal opportunities: any parties unhappy with the decision had recourse only in court.

Option 9 was a dynamic plan formulated around active management, and included land allocation elements of Late Successional Reserves (LSRs), streamside buffers, and Adaptive Management Areas (AMAs). Forty-five LSRs were identified by the presence of significant amounts of old-growth forest on federal lands. Not surprisingly, given the

number of politicians involved, "bells and whistles" were then added to the Standards and Guides that accompanied the decision—and dramatically altered Option 9.

Adopted in 1994, the Northwest Forest Plan is an integrated, comprehensive design for ecosystem management, intergovernmental and public collaboration, and rural community economic assistance for federal forests in western Oregon, Washington, and northern California. Several high-level offices were established in Portland, such as the Regional Ecosystem Office (REO), to oversee various aspects of plan implementation for the administration, and to assure coordination and cooperation between the various land management agencies (USDA Forest Service and USDI Bureau of Land Management) and regulatory agencies (USDI Fish and Wildlife Service, U.S. Department of Commerce National Marine Fisheries Service, and the U.S. Environmental Protection Agency).

In terms of Roberts' (2000) coping strategies, *authority* was essentially the primary strategy resorted to by FEMAT and its several precursors after several failed *competitive* and *collaborative* strategies, and some stakeholders found the resulting plan socially unacceptable. Authority was given primacy again for political and legal modifications to the approaches proposed by scientific experts and others—and made implementing the Northwest Forest Plan impossible.

Here was a situation of such controversy, magnitude, and scope that it required personal intervention by the President of the United States. Yet, despite his high-level involvement, a full decade later the plan has not reached its potential, and the controversy continues to be played out in federal courts. Conflicts between the plan's stated objectives and potential outputs, and the Standards and Guides—which were driven by the precautionary principle, have resulted in dissatisfaction among most of the key players. Plans and projects have continued to be locked up in appeals and litigation and the hoped-for timber "probable sale quantity" of about 1.1 billion board feet has never been approached.

Bondurant's (2001, pp. 45-46) study of the key participants in the Northwest Forest Plan concluded that:

> Despite the fact that the Northwest Plan is an ecosystem management plan, the success of the plan is still questionable. What would seemingly appear to be an environmentalists' dream plan, is not enough. Although it makes great strides, the environmental group interview participants want the matrix (the forest area that is open to active forest management) to have reserve status. The timber industry groups want the reverse, the reserves to have matrix status with timber sales proceeding. In the era of strict environmental laws, the timber industry will never get their wish.
>
> Ecosystem management as seen in the Northwest Forest Plan will not be successful for the following reasons:
>
> - Difference in definition of how preservation is achieved.
> - Fundamental mistrust of motives of groups involved and especially mistrust in the Forest Service knowing what they are doing.

- Using survey and manage to implement goals, trying to provide high likelihood of viable populations of all old-growth[-]related species is not possible[,] along with exorbitant costs.
- Using [a] bottom[-]up, survey and manage approach is contradictory to definitions of how ecosystem management should be implemented….
- The vague nature of the term "ecosystem management" is a hindrance. All groups support ecosystem management but have very different definitions.

In a review of the implementation of the Northwest Forest Plan in northern California, Jack Ward Thomas, the leader of the FEMAT team, concluded (Thomas 2003a):

> The question is not whether the Northwest Forest Plan is sustainable in the technical sense (which it may well be if executed as written and sans requirements for survey and manage in old-growth stands in the matrix scheduled for timber harvest), but whether it is sustainable in the political/legal/economic sense (which it has not been). In short, it is difficult to discuss sustainability of outcomes of a plan that has never been fully executed and tested. And, are social, political and economic sustainability equally as important as sustainability of biological outputs? The actions of the courts and the federal regulatory agencies suggest that the answer to this question is "no."

The results of the *authoritative* strategy in the Pacific Northwest Forest Plan are clear and undesired: an enormously expensive plan that is yet to be implemented due to unworkable processes and insufficient support by affected stakeholders. Moreover, stakeholders with enough authority to impose competitive or authoritative power have nullified the collaborative strategy and honest use of science publicly committed by the federal management agencies' executives. This flawed decision-making process is what changed FEMAT's Option 9 into the untenable Northwest Forest Plan.

The Interior Columbia Basin Ecosystem Management Project (ICBEMP)

Following the Northwest Forest Summit in May 1993, President Clinton also directed the affected federal agencies to develop a comprehensive plan for the Interior Columbia Basin Ecosystem. This effort became known as the Interior Columbia Basin Ecosystem Management Project (ICBEMP) and was initiated by the USDA Forest Service and USDI Bureau of Land Management (BLM) in July 1993 to develop a scientifically sound and ecosystem-based strategy for managing eastside forests. The planning effort responded to several critical broad-scale issues including, but not limited to, forest and rangeland health, the Endangered Species Act listing of Snake River salmon, bull trout protection, local communities' economies, species associated with old-forest structure, and treaty and trust responsibilities to American Indian Tribes.

The Project area encompassed 144 million acres in eastern Oregon and Washington, almost all of Idaho, western Montana, and parts of Nevada, Utah and Wyoming. The

Forest Service and the Bureau of Land Management manage over 71 million acres of this land. Furthermore, about 24% of the National Forest System lands and 10% of the nation's BLM-administered lands were covered by this planning effort.

In terms of Roberts' (2000) coping strategies, the sociopolitical climate evolved into a *competitive* strategy where issues are played out on the battlefield, in politics or the market. In this highly charged and politicized decision-making environment, members of Congress, state governors, local politicians, and well-organized interest groups vied for power and influence. This fierce competition characterizes the Interior Columbia Basin Ecosystem Management Project, where a solution still eludes resource managers a decade later.

The planning process was managed by a Regional Executive Steering Committee composed of the USDA Regional Foresters and Bureau of Land Management State Directors for the affected area. A scientific team was formed and managed by the Director of the USDA Forest Service Pacific Northwest Research Station in Portland, Oregon. The team produced a series of scientific assessments; numerous publications, documents, and analyses were made available to the decision makers, planning team, and the public. An interdisciplinary, interagency planning team ultimately prepared two separate draft planning documents as a result of dissatisfaction with the process's outcomes from powerful political players. The two documents were the Eastside and Upper Columbia River Basin Draft Environmental Impact Study (EIS), which included seven alternatives, and the ICBEMP Supplemental Draft EIS, which included three additional alternatives.

Among all alternatives considered in the case of the Interior Columbia Basin (including the 10 alternatives presented in the two Draft EISs), the Regional Executive Steering Committee "preferred" Alternative S2 , as displayed in the Draft EIS because, in their opinion, it would provide the most defensible and best strategy for restoring the health of the forests, rangelands, and aquatic-riparian ecosystems in the planning area. Further, the plan would permit recovery of sensitive and threatened plants and animals while avoiding future listings of species under the Endangered Species Act, and would provide a predictable level of goods and services from the lands administered by the Bureau of Land Management and the Forest Service. However, the Regional Executive Steering Committee also agreed that in the Final EIS and Record of Decision (ROD), the decision makers could modify the preferred alternative, incorporate elements of the various alternatives analyzed in the Draft EIS and Supplemental Draft EISs, or even select a different alternative as the preferred alternative.

The final outcome was an agreement, in the form of a Memorandum of Understanding, between the federal land management agencies (USDA Forest Service and the USDI Bureau of Land Management), the federal regulatory agencies (U.S. Department of Commerce National Marine Fisheries Agency, USDI Fish and Wildlife Service, and the Environmental Protection Agency), and the USDA Forest Service's Research Stations, to cooperatively implement the "The Interior Columbia Basin Strategy." This Strategy is to guide efforts to update land use plans for individual national forests and Bureau of Land

Management Districts in the planning region. The Strategy provides guidance for incorporating science data and resource information developed by the Project into land and resource management plans and project implementation. It also considers concerns raised by the public throughout the planning process and in the scientific assessments.

After lengthy analysis and costs to taxpayers in excess of $40 million, various influential stakeholders and elected officials intervened to try to either steer the outcome in their favor, or to prevent it from coming to completion. Ultimately, the *competitive* strategy used in the Interior Columbia Basin resulted in no final decision or approved plan that would amend the national forest and Bureau of Land Management plans concurrently and comprehensively, as originally envisioned.

SUMMARY

Most large-scale natural resource planning efforts meet the criteria of being wicked problems. Efforts to deal with such problems through collaborative strategies, through using the precautionary principle, and through adaptive management have not been uniformly successful. Both a collaborative approach to deal with public value conflicts, and adaptive management to deal with scientific and other forms of uncertainty, are necessary; however, they are not sufficient. Agencies and stakeholders continue to seek the "perfect" solution when, by definition, none exists. Further, this elusive perfect solution is defined differently by each participant. This leaves the decision maker in a quandary, having to make a decision when there is no clear agreement or consensus on what to do.

At this point, we have characterized the nature of risk and uncertainty and defined wicked problems. In subsequent chapters, we will look at the case of national forest planning in the Sierra Nevada of the USDA Forest Service's Pacific Southwest Region. We then will review the literature and practice of important decision models and tools, such as the precautionary principle, adaptive management, and participatory processes, in the context of their use and utility in dealing with wicked problems.

CHAPTER 4. MANAGING NATIONAL FORESTS

INTRODUCTION

Is the Sierra Nevada Forest Plan Amendment Process a wicked problem? To answer this question, this chapter provides an overview of the administrative, ecological, and social contexts of the decision problem in the Sierra Nevada national forests. This includes discussing the dispersed management power in the USDA Forest Service organization, the often conflicting federal laws regulating and guiding management and activities in the national forests, the diverse biological environment of the Sierra Nevada Mountains, and the complex social and political environment in which decisions must be made. We explore the resulting management dilemma facing the Forest Service in California, followed by historical and contemporary looks at the Sierra Nevada Forest Plan Amendment process. Finally, we compare the Sierra Nevada situation point-by-point with the definition and characteristics of a wicked problem as described in Chapter 3, and conclude that the Sierra Nevada Forest Plan Amendment process is indeed a classic wicked problem.

MANAGEMENT ENVIRONMENT: COMPLEX

National Forests of the Sierra Nevada: Power Dispersed

There are 10 national forests and 1 USDA Forest Service administrative unit located in California's Sierra Nevada Mountains: the Humboldt-Toiyabe, Modoc, Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Inyo, and Sequoia National Forests, and the Lake Tahoe Basin Management Unit (Figure 5). These units cover about 11.6 million acres of important forest and non-forest ecosystems (Table 3).

Figure 5. The National Forests of the Sierra Nevada

These national forests are part of the Forest Service's Pacific Southwest Region, except for the Humbolt-Toiyabe, which is part of the Intermountain Region. Administrative responsibility for the Region is vested in the Regional Forester and his or her staff of technical specialists and Deputy Regional Foresters. Each national forest is, in turn, headed by a Forest Supervisor who is responsible within legal authorities, agency regulations, and allocated funds, to carry out the agency's mission. In

turn, each forest is further subdivided into smaller administrative units, called Districts or Ranger Districts, each supervised by a District Ranger. Historically, the Forest Service was managed as a decentralized organization with significant authority delegated "close-to-the-ground." Of about 35,000 employees, fewer than 1,000 are in the national headquarters in Washington, DC.

As a result of decentralization and the location of Congressional districts, much of the agency's historical political power base is at the Region and/or Forest level. It is not uncommon for members of Congress to take a very personal interest in their local national forests' activities and plans, especially in the western United States, where national forests may occupy 50% or more of a county's total land area. In fact, it is not uncommon for specific local national forest projects and programs to be "earmarked" for special funding in the Forest Service annual appropriations.

Table 3. Total Acreage by National Forest in the Sierra Nevada

Forest	Total Acreage
Eldorado	599,203
Humboldt-Toiyabe	635,995
Inyo	2,040,660
Lassen	1,150,916
Modoc	1,677,873
Plumas	1,229,245
Sierra	1,320,376
Stanislaus	897,907
Sequoia	1,111,194
Tahoe	820,327
Tahoe Basin MU	151,215
Total	**11,634,911**

Laws Governing Managing National Forests: Conflicting Direction

The national forests were initially established in the western United States under the Creative Act of 1891, which permitted the president of the United States to withdraw lands from the Public Domain as forest reserves. In 1897, the Organic Administration Act provided specific purposes for establishing the forest reserves (USDA Forest Service 1993):

> No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States; but it is not the purpose or intent of these provisions, or of the Act, to authorize the inclusion therein of lands more valuable for the mineral therein, or for agricultural purposes, than for forest purposes.

Forest reserves were under the jurisdiction of the Government Land Office in the U.S. Department of the Interior until 1905, when they were transferred to the Forest Service in the U.S. Department of Agriculture by the Transfer Act.

Direction for administering these lands was provided in a letter sent to the Chief of the Forest Service, Gifford Pinchot, by Secretary of Agriculture James Wilson on February 1, 1905 (USDA Forest Service 1993):

> In the administration of the forest reserves it must be clearly borne in mind that all land is to be devoted to its most productive use for the permanent good of the whole people and not for the temporary benefit of individuals or companies. All the resources of forest reserves are for use, and this use must be brought about in

> a thoroughly prompt and businesslike manner, under such restrictions only as will insure the permanence of these resources.
>
> You will see to it that the water, wood, and forage of the reserves are conserved and wisely used for the benefit of the home-builder first of all; upon whom depends the best permanent use of the lands and resources alike. The continued prosperity of the agricultural, lumbering, mining, and livestock interests is directly dependent upon a permanent and accessible supply of water, wood, and forage, as well as upon the present and future use of these resources under businesslike regulations, enforced with promptness, effectiveness and common sense.
>
> In the management of each reserve local questions will be decided upon local grounds; the dominant industry will be considered first, but with as little restriction to minor industries as may be possible; sudden changes in industrial conditions will be avoided by gradual adjustment after due notice; and where conflicting interests must be reconciled, the question will always be decided from the standpoint of ***the greatest good of the greatest number in the long run*** [emphasis added].

Pinchot prepared this letter of instruction for the Secretary (Pinchot 1947), and it reflected the dominant thinking of time: the Progressive Movement. Both Pinchot and President Theodore Roosevelt, who were close personal friends, were leaders in the Progressive Movement. Although the Forest Service's legislative direction has been expanded and modified over time, the legacy of the Progressive Movement—especially scientific management, and the direction provided in the Secretary's 1905 letter, have continued to guide the agency's management to the present (Nelson 1999; 2000). Consequences of this thinking are (Fairfax and Fortmann 1990):

> preeminent emphasis on technical expertise as the basis for decision making; a related tendency to prefer comprehensive government planning and to denigrate the expertise and priorities of local resource users, who are seen as political advocates serving their own special interests; a preference for managing trees, for lumber and as distinct from other forest and tree uses.

With respect to the issues in the Sierra Nevada, modern national forest management is guided by five principle laws: the Multiple Use–Sustained Yield Act of 1960 (MUSY), the National Environmental Policy Act of 1970 (NEPA), the Endangered Species Act of 1973 (ESA), the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), and the National Forest Management Act of 1976 (NFMA).

<u>Multiple Use–Sustained Yield Act</u>

1960's Multiple Use–Sustained Yield Act supplemented the purposes for establishing the national forests found in the Organic Act of 1897. MUSY states that "it is the policy of the Congress that the national forests are established and shall be administered for

outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (USDA Forest Service 1993).

The Act further defines "sustained yield" as "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the National Forests without impairment of the productivity of the land" (USDA Forest Service 1993).

National Environmental Policy Act

The National Environmental Policy Act of 1970 established a national policy to encourage (USDA Forest Service 1993):

> productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation.

Each federal agency is required to use a systematic, interdisciplinary approach in planning and decision making for activities that may potentially impact the environment, which will insure integrating the natural and social sciences and the environmental design arts. The Act specifies a public process for the responsible federal official to consider (USDA Forest Service 1993):

- the environmental impact of the proposed action,
- any adverse environmental effects which cannot be avoided,
- alternatives to the proposed action,
- the relationship between local short-term uses of our environment and maintaining and enhancing long-term productivity, and
- any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Endangered Species Act

1973's Endangered Species Act of 1973 provides that agencies

- not take actions that would result in listing a plant or animal species;
- take actions that would promote recovery of listed species; and
- consult with the appropriate regulatory agencies (USDI Fish and Wildlife Service for plants, animals, and most fish species, and U.S. Department of Commerce National Marine Fisheries Service for marine and anadromous fish, such as steelhead and salmon) in considering actions that may affect listed species.

Forest and Rangeland Renewable Resources Planning Act

The Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 provides that (USDA Forest Service 1993):

> the Secretary of Agriculture shall develop, maintain, and, as appropriate, revise land and resource management plans for units of the National Forest System,

> coordinated with the land and resource management planning processes of State [sic] and local governments and other Federal [sic] agencies.

The plans are to use a systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences. Further, the Secretary is to provide for public participation in developing, reviewing, and revising land management plans. Public participation is to include (USDA Forest Service 1993):

> making the plans available to the public at convenient locations in the vicinity of the affected units for at least three months before final adoption, during which period the Secretary shall publicize and hold public meetings of comparable processes at locations that foster public participation in the review of such plans or revisions.

National Forest Management Act

In 1976 Congress amended the RPA by passing the National Forest Management Act as a result of continuing controversy about national forest management practices, especially the agency's expanded use of clear-cutting. The Act established timber sale processes to assure competition and fully utilizing wood materials removed from national forests. It also placed limitations on the use, arrangement and size of clear-cuts (USDA Forest Service 1993). Finally, it amended Section 6 of the RPA.

Of specific interest in the current context, Section 6(g)(3)(A) requires that plans consider the economic and environmental aspects of various systems of renewable resources management, including the related systems of silviculture and protecting forest resources, to provide for outdoor recreation, range, timber, watershed, wildlife, and fish. Section 6(g)(3)(B) further states that the plans (USDA Forest Service 1993):

> provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives, and within the multiple-use objectives of the land management plan adopted pursuant to this section, provide, where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan.

A Committee of Scientists was convened to help develop the regulations implementing the NFMA. In this process, the requirement to "provide for diversity of plant and animal communities…" (Section 6(g)(3)(B)) was established to maintain "viable populations" of all species throughout their range. This has proven to be difficult in practice.

The National Environmental Policy Act and the National Forest Management Act have especially rich litigious histories. Forest plans and individual projects, especially those involving timber sales, are often appealed and then litigated. This has led to preparing lengthy and complex planning and decision documents to meet court requirements for sufficiency, and to provide some degree of safety from lawsuits.

The development of the legislation governing national forest use and management, beginning with the Organic Act in 1891 and ending with the National Forest Management Act of 1976, reflects changing public values toward public lands. Early

concerns were towards commercial use, particularly in support of western expansion and developing associated local communities. To maintain support for removing public domain lands from disposal to individuals and to commercial interests, such as railroads, early laws contained provisions for commercial use and development of forest reserves and later the national forests. Many western U.S. communities were dependent upon the federal lands for economic development, and western members of Congress carefully guarded continued use rights. Compared with the size of the resource base, early uses remained relatively low due to the small population.

Initial national forest management was largely custodial, focusing on watershed protection, forest restoration (especially on cutover forest lands and abandoned farmland in the eastern U.S. purchased under the Weeks Act of 1911), fire prevention and suppression, and controlling overgrazing. At the beginning of World War II, the need for wood to support the war effort resulted in large increases in timber harvests in the national forests (Figure 6). Following the war, harvesting continued at an accelerated rate to meet the needs for low-cost housing.

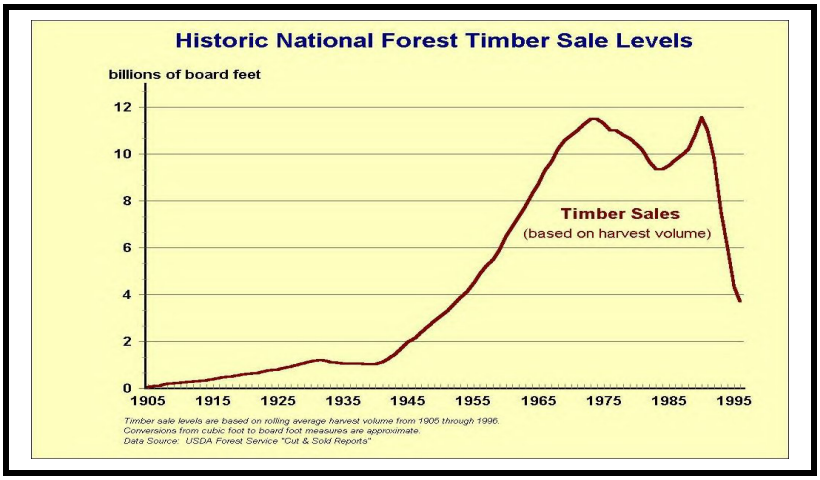


Figure 6. Historic National Forest Timber Sale Trends. From USDA Forest Service Forest Management Staff, Washington, DC (USDA Forest Service 1996)

Beginning with the environmental movement in the 1960s, public attitudes and values toward using the national forests began to shift dramatically.

The Multiple Use–Sustained Yield Act of 1960 was an attempt to recognize and bring balance to a full range of national forests uses. This was followed by the Wilderness Act of 1964 and, later, by opening the decision-making process to public scrutiny through the National Environmental Policy Act and Renewable Resources Planning and National Forest Management Acts of the mid-1970s.

However, in the give-and-take of political compromise, and to maintain support from powerful western members of Congress, the new laws continued to allow development and commercial forest use, creating an eventual conflict: on the one hand supporting development, and on the other requiring increasing levels of protection and caution in management. The forest planning process mandated under RPA and NFMA resulted in increasing land allocations for other uses and needs. The planning's interdisciplinary nature also brought new perspectives and interests to the table, combined with the need to maintain viable species populations, and to prevent listing species or to provide recovery for listed species, led to an inevitable collapse of the historic timber sale program

becoming evident in the late 1980s. Today pressures continue from members of Congress with national forests in their districts, albeit at a reduced level, to maintain commodity outputs from the national forests. At the same time, many members of the public, especially from urban areas, oppose continued commercial use of public lands.

BIOLOGICAL ENVIRONMENT: DIVERSE AND SCIENTIFICALLY UNCERTAIN

Extensive biological and physical diversity in the California's Sierra Nevada region necessitates briefly describing the most crucial points. This information is taken from the Final Environmental Impact Statement for the Sierra Nevada Forest Plan Amendment, Volume 2, Chapter 3, Part 2, pp. 30-78 (USDA Forest Service 2001a).

Vegetation Diversity

The diversity of the Sierra Nevada's old forests reflects the regions' great variations in topography, soils, climate and vegetation (Barbour and Majors 1990). Giant sequoia forests with trees that are thousands of years old and of a stature unparalleled in the world differ vastly from pine-dominated, open park-like stands in the Sierra Nevada's arid east side. Even within the mixed conifer forests on the Sierra Nevada's west side, the old forests' composition and structure varies from north to south (Walker 1995; Davis and Stoms 1996), and with slope position or aspect within a given watershed (Fites-Kaufman 1997). These different vegetation types also have different histories, with most effects of human settlement and timber harvest in the lower elevation forests, and little to none in the subalpine forests (McKelvey and Johnson 1992; Chang 1996; Franklin and Fites-Kaufman 1996).

Disturbance Diversity

One of the most characteristic ecological processes in the Sierra Nevada has been wildfire (Skinner and Chang 1996). The combination of dry summers, lightning, and pre-European settlement Native American fire use resulted in a natural fire regime of generally frequent (return intervals less than 25 years), low-intensity surface or ground fires. Historically, a lightning strike might ignite a slow-burning fire in late spring or early summer that burned over large areas until winter precipitation put the fire out. The coincidence of local fuel accumulations and dry weather resulted in crown fires that created small openings in the forest canopy of 0.4 to 2.0 hectares in the southern Sierra Nevada, where regeneration of shade-intolerant species, such as pines and giant sequoia, could occur. Such fires prevented general build-up of understory plants and forest floor litter. While the Sierra Nevada forests were extremely diverse in structure and composition, early settlers commonly reported that the forests were open and park-like with large trees in the overstory (Figure 7).

Large forest areas sustained impacts from early logging practices that removed the most valuable, shade-intolerant and fire-resistant overstory pines, leaving the more fire-susceptible and shade-tolerant understory white fir. With the advent of national and state wildfire suppression policies beginning in the early 1900s, natural wildfire processes have been severely interrupted in the Sierra Nevada. This combination has resulted in changed forest composition and stand structure. Today's forests have more shade-tolerant species and more understory than in pre-European settlement times (Figure 8). Absence of fire has allowed understory trees to reach up into the overstory canopy, and forest floor litter has accumulated.

These forests are much more prone to crown fires and smoldering ground fires that kill trees.

Figure 7. Sierra Nevada Mixed Conifer Forest in Nevada County, California Before Logging, c. 1890-1915. (Gruell 2001)

Fire, insects and pathogens in Sierra Nevada forests historically produced light to moderately severe effects: many forests typically survived fire (Chang 1996; Skinner and Chang 1996), drought, or insect and pathogen outbreaks (Ferrell 1996). Fire most often killed the smaller trees. Individual trees or several large trees might be killed, but most often in small areas. As a result, the concept of fire, insects or pathogens resetting forests into readily recognizable stages of growth—termed seral or successional stages—does not apply to most historical processes in the Sierra Nevada, nor to the predominately selective timber harvest that has been most prevalent (Franklin and Fites-Kaufman 1996). Therefore, old forests often occur in spatially complex patterns, with mosaics of patches with different structural levels, bounded by indistinct boundaries. Thus, the silvicultural definition of "stands" as areas of uniform forest structure (Oliver and Larson 1996) does not apply to most old forests in the Sierra Nevada. These interactions of forest structure and fire, insects, pathogens, and climate resulted in what is hypothesized to be a fine-scale spatially heterogeneous pattern in old forests (Bonnicksen and Stone 1981; Franklin and Fites-Kaufman 1996; Franklin, Graber et al. 1997).

Figure 8. Fuels Accumulation in Sierra Nevada Forests. (USDA Forest Service 2002a)

Twentieth-century fire regimes in the Sierra Nevada are very different from pre-European contact fire regimes: Intervals between present-day fires are longer, allowing more time for fuels and vegetation to accumulate. As a result, fires have more fuel to burn, become more severe, kill more vegetation, and are more difficult and dangerous to control. This volatility also strongly suggests that existing late-seral and old-growth forests are more susceptible to loss from stand replacement fires than under more natural fire regimes.

Landscape Diversity

This characteristic pattern of fine-scale old forest structure results in incorporating shrubs and small trees (forests' early- and mid-seral components) within a stand and in the larger landscape characterized by the presence of old trees. On the other hand, Franklin and Fites-Kaufman (1996) conclude that old forest stands in the Sierra Nevada incorporate the large tree aggregates and individuals and the intermixed younger forest in a mosaic; further, the occurrence and pattern of mosaics of patches with large trees at the landscape scale are important to some old forest processes and functions as well. In forest management, all of these scales must be considered because animal species associated with old forest structure occupy home ranges of widely varying sizes: from small areas occupied by small mammals to landscape areas occupied by wide-ranging raptors such as the California spotted owl, or carnivores such as the Pacific Fisher. Moreover, individual old forest structures such as a large snag, log or large tree may be important for nesting or resting habitats regardless of how many large trees are in the surrounding stand.

Species Diversity

The Sierra Nevada's varied landscapes support a rich diversity of plant and animal species—some of which are found only in the Sierra Nevada. Species vary greatly in abundance and distribution, from very abundant and widespread to extremely rare and locally distributed. More than 550 vertebrate species have been identified, including approximately 30 amphibian, 35 reptile, 130 mammal, 270 bird, and 95 fish species (USDA Forest Service 2001a). While a complete inventory of plants does not exist, more than 3,500 vascular plant species and thousands more nonvascular plant species may occur in the Sierra Nevada (Shevock 1996). An unknown number of invertebrate species also occur. Existing invertebrate surveys are generally limited to select groups of insects in geographically restricted areas (Erman 1996; Kimsey 1996; Shapiro 1996).

As described earlier, two federal laws govern species management on National Forest System lands: the Endangered Species Act (ESA) and the National Forest Management Act (NFMA). The ESA directs all Federal agencies to conserve endangered and threatened species (ESA 1973, Sec. 2(c)(1)) by providing a means whereby the ecosystems upon which endangered and threatened species depend may be conserved (ESA 1973, Sec. 2(b)). NFMA mandates that plant and animal species' diversity be provided as consistent with overall multiple-use goals (Section 6(g)3(B)), while regulations for planning under NFMA (36 CFR 219.19) require that fish and wildlife habitat be managed to maintain viable populations of existing native and desired non-native vertebrate species throughout the planning area. NFMA regulations also direct the Forest Service to preserve and enhance plant and animal communities' diversity,

including native and desirable naturalized plant and animal species, such that diversity mimics what might be expected under natural conditions, where appropriate and to the extent practicable (36 CFR 219.27(g)).

As discussed in Chapter 3, events in forest ecosystems are characterized by multiple determinants (Kimmins 2003). In multiple determinism, events vary in their predictability from high to low. Its importance to the management situation in the Sierra Nevada is captured by Kimmins (2003):

> Successful forest management requires the correct choice from among alternative methods of attaining management objectives. Such a choice requires the ability to predict the outcomes of the various alternatives so that the best can be selected. Accurate prediction is difficult in a forest because of the complexity of factors responsible for determining events and conditions. Accurate prediction in complex systems is possible, however, if the components and functional processes of the system are understood.

Therefore, even the best models available are not likely to accurately predict the outcomes for complex ecosystems such as those found in the Sierra Nevada, and surprises should be expected.

SOCIOPOLITICAL ENVIRONMENT: SHIFTING DEMOGRAPHICS AND DIVERSE VALUES

Native Americans lived in the Sierra Nevada for thousands of years, while Americans of European ancestry are relative newcomers, arriving during the latter half of the nineteenth century (USDA Forest Service 2001a). These latecomers brought significant change to the landscape (Duane 1996). Settlers transformed foothills with agricultural practices, resulting in introducing new plant and animal species. Discovering gold in 1848 brought as many as 100,000 miners to the Sierra Nevada. Mining, constructing the transcontinental railroad through the central Sierra Nevada, and population growth, resulted in extensively logging low- to mid-elevation pine and mixed conifer forests. Sierra Nevada communities' local economies were largely dependent on exploiting natural resources into the mid- to late-1900s.

Today, people in the Sierra Nevada make their livings in a wide variety of ways. Local ecosystems are used for traditional cultural subsistence, scientific and educational exploration, logging, mining, and recreation. Many residents commute to metropolitan areas in the Central Valley, while others who live in those metropolitan areas visit the Sierra Nevada on weekends. While some communities are still dependent upon their adjacent national forests' resources, increasingly the Sierra Nevada's economies are being driven by other economic sectors. Figure 9 reveals the overall social environment.

The Sierra Nevada counties contain about 3.8 million people (about 11% of the combined total California and Nevada populations) and this population's demographics are undergoing significant change (USDA Forest Service 2001a). Between 1989 and 1999, population has grown 15 % in the most northern Sierra Modoc Plateau area, 29% in the north central Gold Country area, 21% in the south central Mother Lode region, and 25%

in the southern Sierra (USDA Forest Service 2001a). Madera and Placer counties experienced a 40% increase. This compares with a growth rate of 17% for the State of California during the same period. About 60% of the people in the Sierra Nevada live on less than 1% of the land base. This population growth has taxed the counties' infrastructures and has resulted in increased demands on water and forest resources. It also has resulted in a new wildland fire fuel type and associated hazard—"pine overstory and shake roof understory."

Figure 9. Summary of the Sierra Nevada Social Environment

Recent Population Growth: Population doubled in the Sierra Nevada between 1970 and 1990; 40% of the population growth occurred in the Sierra portion of just three counties: Nevada, Placer, and El Dorado.
Population Forecasts: Official projections forecast that the 1990 Sierran population of 650,000 will triple by 2040.
Impacts from Population Growth: Population growth and its accompanying effects are causing significant impacts on resources.
Jobs: The number of jobs has more than doubled in the Sierra Nevada since 1970, but the relative proportion of commodity-producing and service-producing jobs has stayed constant.
Personal Income: Income earned by commuters, interest, dividends, and transfer payments to retired and other households now constitute more than half the total personal income in the Sierra Nevada.
Ecosystem-Based Revenues: Water is the most valuable commodity, followed by timber, livestock, and other agricultural products, based on gross revenues. The Sierra Nevada ecosystem produces approximately $2.2 billion worth of commodities and services annually, based on estimates of direct resource values (not the total revenue produced by resource-dependent activities).
Regional Patterns of Economic Activity: The flow of economic values from the Sierra Nevada provides an empirical basis for assessing how different levels of government, producers and consumers, and employers and employees could be involved in new approaches to ecosystem management.
Community Dependence: Communities in the Sierra Nevada are dependent on the ecosystem for a combination of direct and indirect natural resource benefits, including noneconomic benefits associated with aesthetic and sense-of-place values. Few economies are dependent exclusively on resource-extractive activities (timber, mining, grazing).
Timber-Based Employment: Timber industry employment may decline from present levels due to trends of increasing labor productivity within the region and a shift in remanufacturing facilities out of the region.
Community Well-Being: One-hundred-eighty communities were identified in the Sierra: twenty-eight ranked low and thirty-one ranked high in a measure of well-being that includes community capacity and socioeconomic status.
Concentration of Low Socioeconomic Status: Sierra residents living in poverty are concentrated in the larger cities and communities. (Sierra Nevada Ecosystem Project 1996)

The Federal Wildland Fire Management Policy and Program Review was chartered by the Secretaries of the Interior and Agriculture to ensure that federal policies are uniform and programs are cooperative and cohesive (U.S. Department of Interior and U.S. Department of Agriculture 1995). The Federal Wildland Fire Policy has firefighter and public safety as its number one priority, reaffirming protecting human life as the first priority in wildland fire management. Property and natural/cultural resources jointly are the second priority, with protection decisions based on values to be protected and other considerations. While the Policy focuses on fire management, as opposed to the historical emphasis on fire suppression, practically and politically must give priority to saving structures and human lives in the area where development and wildlands meet: the wildland–urban intermix. This focus increases firefighting costs and, potentially, puts emphasis on both fuels management and fire suppression in the wildland–urban intermix zone—at the expense of undeveloped wildlands.

The population's ethnic diversity varies subregionally, with the highest proportion of Hispanic and Asian/Pacific Islanders in Fresno County, and Native Americans in Washoe County. In 1998, more than 75% of residents in all but the Southern Sierra and Carson Range subregions were white (USDA Forest Service 2001a). Black Americans comprised 12% of the population in Mineral County and 10% in Lassen County, exceeding the statewide average. American Indians were more than a quarter of Alpine and Mineral Counties' residents in 1998. As the region's population grows, its residents' ethnic composition will also change. By 2010, the Southern Sierra Region's population is expected to grow by 29% above 1998's. During this period, the Hispanic population is expected to surpass that of white residents in Fresno and Tulare Counties; all counties are projected to have larger Hispanic populations. Other ethnic groups, except whites, are expected to remain about the same as in 1998 (USDA Forest Service 2001a).

Public values towards using the national forests have changed dramatically since their creation out of the Public Domain beginning in 1891. Born out of the Progressive Era of Gifford Pinchot and Teddy Roosevelt (Pinchot 1947; Nelson 1999), the national forests historically serve a utilitarian purpose: to meet the people's needs, especially in the western U.S., for wood, water, forage, and economic development. For the majority of national forests' existence, this land management philosophy received general public and Congressional support. Today, though, there is a sharp dichotomy in public values, and support for developing the national forests is divided. Some continue to favor development, especially in locally national forest-dependent communities, such as some of those in the Sierra Nevada. Others strongly oppose any economic and extractive forest uses, especially timber harvesting, but also extending to livestock grazing and mining. Still others oppose uses that present potential environmental degradation or interfere with enjoyment of forests' spiritual and esthetic values, such as off-road vehicle use.

Views vary widely over how the national forests should be managed to sustain desired environmental conditions and best meet people's economic and social needs. Some recommend, for example, that management should favor conditions that result largely from nature's forces and processes over social and economic uses. Others favor the opposite, concluding that high levels of natural resource production and use are compatible with sustaining desired ecosystem conditions. Some recommend that, because local communities have such clear cultural, traditional, social, and economic stakes in the national forests, their voices and needs ought to be given significant consideration in designing and carrying out conservation policy. Still others are mindful that the national forests must serve everyone's needs, present and future, and that those needs should be provided equal weight with environmental concerns when designing conservation policy.

Changing demographics in rural Sierra Nevada communities mean these conflicting societal values are playing out in local politics and planning efforts, such as those facing the Forest Service. Old-line community members who obtained their livelihoods from commercial uses of the national forests are increasingly coming into conflict with newer residents who moved to the community to escape the hectic lifestyle of urban living.

MANAGEMENT'S DILEMMA

In characterizing the decision environment the Forest Service faces in the Sierra Nevada case (Figure 10), we find three main drivers influencing forest ecosystems over time:

1. external human factors, associated with both neighboring communities and the broader interested public;
2. natural events and processes largely beyond the agency's control—including lightning strikes, droughts, plant community succession, and long-term climatic changes; and
3. Forest Service management strategies and practices.

These three inputs affect forest ecological conditions. These ecological effects are then translated into outcomes, such as wildfire acres burned, old-growth habitat gained or lost, and timber volume produced. In turn, these ecological effects and outcomes, both observed and projected, influence stakeholder acceptance of and reaction to Forest Service management activities. But stakeholders do and will evaluate Forest Service management decisions on factors other than ecological outcomes: Whether because of uncertainty, lack of trust, or some other reason, stakeholders also scrutinize and evaluate the Forest Service based on its management choices and the processes used to arrive at those choices.

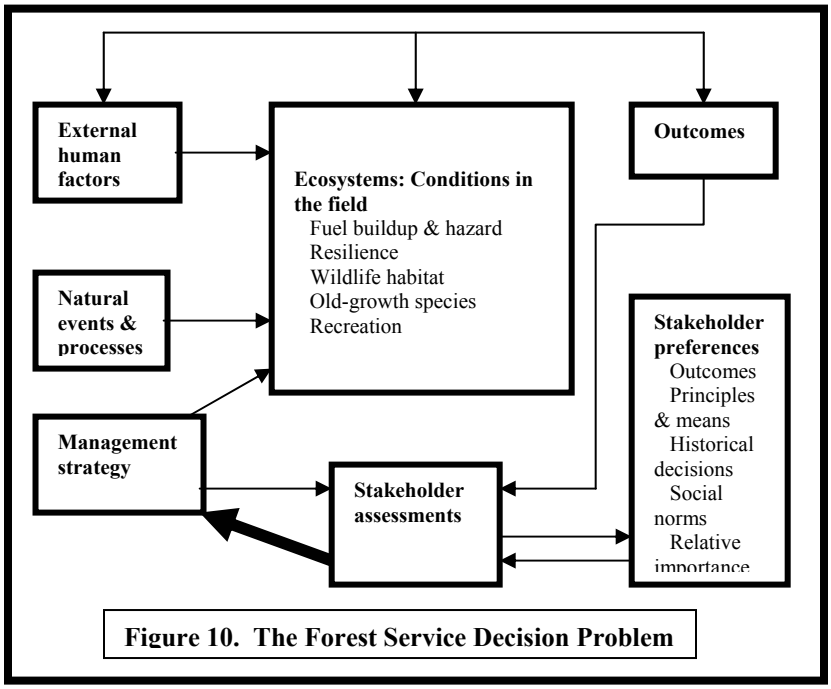


Figure 10. The Forest Service Decision Problem

In addition to holding varying preferences regarding processes and outcomes, stakeholders diverge in their understanding of—and aversion to or tolerance for—the range of risks and uncertainties associated with forest management in the Sierra Nevada case. Stakeholders, acting on their preferences and levels of risk aversion or tolerance, influence the Forest Service's management strategies and practices through various mechanisms including participating in public meetings and other opportunities for public comment, bringing political influence to bear, and initiating formal appeals and legal challenges.

THE SIERRA NEVADA FOREST PLAN AMENDMENT PROCESS

The history of the development of the Sierra Nevada Forest Plan Amendment and the 2003 effort to revise the Record of Decision (ROD) through a Supplemental Environmental Impact Statement follows, first in timeline form and then in greater detail. A full description of the alternatives considered can be found in the Final Environmental Impact Statement (USDA Forest Service 2001a).

Chronology of Key Events

The following chronology of events related to the Sierra Nevada Forest Plan Amendment process was obtained from Beesley (n.d.)

- **1989—**A policy of defining and establishing Spotted Owl Habitat Areas (SOHAs) is initiated the Pacific Southwest Region of the USDA Forest Service (the Region) as a conservation strategy for California spotted owl habitat.

> Early research on status and viability of the California spotted owl (Verner, McKelvey et al. 1992) showed that certain owl habitats were at risk. Interim management guidelines to protect California spotted owl populations were recommended until a more comprehensive management plan could be developed. An environmental assessment was prepared for these interim guidelines, which are commonly known as the CASPO guidelines, and a Decision Notice was issued on January 13, 1993.

- **Early 1990s—**Monitoring by the Region and by scientists suggests that California spotted owl populations are in continuing decline. The Forest Service begins to assess management for the northern spotted owl, and in the process identifies serious weaknesses in the SOHA strategy—which was being used for both northern and California spotted owls. These weaknesses strongly suggest that a very different approach is needed for conserving spotted owl populations.
- **July 1992—**Forest Service publishes "The California Spotted Owl: A Technical Assessment of Its Current Status" (Verner, McKelvey et al. 1992)
- **January 1993—**Forest Service completes an environmental assessment (EA) that proposes adopting a set of guidelines for owl conservation based on the Technical Assessment (Verner, McKelvey et al. 1992)

> A draft environmental impact statement (DEIS) for conserving California spotted owl habitat was prepared in 1995. However, significant new information was identified during the public comment period on that DEIS. Therefore, a revised draft EIS (RDEIS) was developed and scheduled for release in summer 1996. As the release date neared, the Secretary of Agriculture halted release pending a science review, and then chartered a Federal Advisory Committee in May 1997. The Federal Advisory Committee concluded its work in Fall 1997, and found that the California Spotted Owl RDEIS was insufficient, either as a California spotted owl habitat management plan or as a broader ecosystem management plan (Verner, McKelvey et al. 1992; Federal Advisory Committee 1997). The findings of the Federal Advisory Committee were significantly influenced by the SNEP report submitted to Congress in June 1996.

- **January 1993—**Regional Forester signs a "Finding of No Significant Impact (FONSI) for the California Spotted Owl Sierran Province EA" formally adopting these guidelines as an interim measure to protect owl habitat until a permanent strategy is in place.

- **May 1993—**Pacific Southwest Region begins preparing an environmental impact statement (EIS) to develop a long-term strategy to preserve the owls.
- **February 1995—**A Draft Environmental Impact Statement (DEIS) is released.
- **1996—**During DEIS review, additional information is identified and is reflected in a revised DEIS (RDEIS).
- **June 1996 to March 1997—**The Sierra Nevada Ecosystem Project (SNEP) report authorized by Congress to scientifically review the entire Sierra Nevada ecosystem and assemble the comprehensive data necessary for policy decisions is made public.
- **May 1997—**Secretary of Agriculture charters a federal advisory committee (FAC) to review the revised DEIS.
- **December 1997—**The FAC committee's report is critical of the revised DEIS, concluding that it is insufficient as either an owl habitat management plan or a broader ecosystem management plan. This report is part of an ongoing shift as the process moves from a single-species approach to one that encompasses a broader view of the Sierra Nevada ecosystem (Federal Advisory Committee 1997).
- **1998—**Shortly after the FAC is convened, the U.S. Senate Subcommittee on Forest and Public Land Management and the House Subcommittee on Forests and Forest Health form the California Forest EIS Review Committee to evaluate the revised DEIS.
- **1998—**Chief of the Forest Service directs the Pacific Southwest Region to consider the FAC committee's recommendations, especially the information in the Sierra Nevada Ecosystem Project report, and to develop an ecosystem strategy to conserve the California spotted owl, old forests and other forest resources.
- **May 1998—**California Forest EIS Review Committee releases its findings: the revised DEIS was scientifically sound and complete.
- **Summer 1998—**After informal discussions among state and federal agencies, the Forest Service begins a new EIS process, now called the Sierra Nevada Framework.
- **September 1998—**Forest Service convenes a statewide gathering of citizens to encourage dialogue and idea sharing about how best to sustain Sierra Nevada ecosystems and communities.
- **August 1999—**Forest supervisors of the Lassen, Plumas and Tahoe national forests sign a Record of Decision (ROD) for the Herger-Feinstein Quincy Library Group Forest Recovery Act's (HFQLG) Final EIS project.
- **May 2000—**The DEIS for the Sierra Nevada Forest Plan Amendment (SNFPA) is released.
- **January 12, 2001—**Forest Service releases the ROD for the SNFPA.

The U.S. Senate Subcommittee on Forest and Public Land Management, and the House Subcommittee on Forests, requested forming the California Forest EIS Review Committee. In September 1997, the California Forest EIS Review Committee released a draft report finding that the RDEIS had indeed reviewed all relevant information available at the time, and that it had followed appropriate procedures, including adequately using modeling techniques and databases. In May 1998 the California Forest EIS Review Committee released its final report—affirming the findings reported in its draft.

- **April 2001—**National Association of Forest Service Retirees issues a review of the FEIS and ROD, finding that the selected alternative may not sustain forest resources, especially old forests associated with critical wildlife habitats (National Association of Forest Service Retirees 2001).
- **April 2001—**Forest Service receives 276 appeals, of which 234 were submitted in a timely manner. In the response to the appeals signed by Chief Dale Bosworth, the agency states that never before have so many appeals been received on a particular project.
- **November 16, 2001—**Forest Service Chief affirms the SNFPA ROD, but directs the Regional Forester to review certain elements.
- **December 26, 2001—**U.S. Department of Agriculture Undersecretary declines to conduct a discretionary review.
- **December 2001—**Regional Forester charters the SNFPA Review Team to evaluate the SNFPA for any needed changes relative to the concerns identified by the Chief.
- **March 6, 2003—**SNFPA Review Team issues its recommendations to the Regional Forester in a report titled "Sierra Nevada Forest Plan Amendment Management Review and Recommendations."
- **March 18, 2003—**Regional Forester makes his proposal to improve Sierra Nevada Framework.
- **April 2003—**Forest Service publishes a Notice of Intent to prepare a supplemental EIS for the Regional Forester's proposal to improve the SNFPA.
- **June 5, 2003—**Regional Forester issues a new draft Supplemental EIS (DEIS) that documents new information since the Framework decision and analyzes the effects of 10 alternatives. The preferred alternative proposes to reduce impacts on recreationists, grazing permit holders, and rural communities, while allowing harvesting medium-sized trees to help offset the costs of removing smaller trees for fuels reduction.
- **January 22, 2004—**Regional Forester issues Record of Decision and Final Supplemental Environmental Impact statement amending the January 12, 2001 decision.

Key Events in Detail

The California Spotted Owl and Interim Direction

The growing controversy over old-growth forests and their associated dependent species ultimately led to a federal court decision in 1991 that the Forest Service's strategy to protect the northern spotted owl's habitat was insufficient to meet the Forest Service's regulation requirement to maintain viable populations of the owl throughout its range. This conclusion called into question a similar strategy for a related species, the California spotted owl. Regional Forester in the Pacific Southwest Region Ron Stewart requested a scientific assessment of the California spotted owl's status. The 1992 report found that, in fact, the strategy then in use was inadequate (Verner, McKelvey et al. 1992). The report also recognized a significant risk to spotted owl habitat from catastrophic wildfire, and recommended an interim strategy of aggressive thinning from below to reduce

understory fuels. This recommendation was implemented through preparing an Environmental Assessment and issuing a Finding of No Significant Impact (FONSI) decision in January 1993. The FONSI was based on the belief that although there was a significant reduction in timber harvest and expected economic impacts, the impacts would be of short duration. A full assessment and development of an Environmental Impact Statement for a long-term direction was planned for completion within two years.

Two Draft Environmental Impact Statements

The process for developing the long-term strategy began in May 1993 with establishing an interdisciplinary planning team. Public meetings and scientific community engagement began almost immediately to define the scope of the planning effort and to identify relevant science. Regional Forester Ron Stewart charged the team to develop a state-of-the-art ecosystem management plan for the Sierra Nevada national forests within the boundaries of the Pacific Southwest Region (the Humboldt-Toiyabe National Forest, part of the Intermountain Region, was added to the planning effort at a later date). The team was further asked to provide a high degree of protection for riparian areas and to be sure that in providing protection for the California spotted owl, actions taken under the plan would not harm other species. They were also asked to consider an approach in one of the alternatives that would implement the Quincy Library Group proposal, and another alternative that would attempt to mimic natural patterns of disturbance across the landscape.

In 1993, a scientific review of the Sierra Nevada called the Sierra Nevada Ecosystem Project (SNEP) was requested by Congress in the Conference Report for Interior and Related Agencies 1993 Appropriation Act (H.R. 5503), with the urging and support of California Congressman George Miller. The request authorized funds for a

> scientific review of the remaining old growth in the national forests of the Sierra Nevada in California, and for a study of the entire Sierra Nevada ecosystem by an independent panel of scientists, with expertise in diverse areas related to this issue.

The U.S. Forest Service augmented support for the study and convened a steering committee to help draft the charge and select the Science Team. The Steering Committee had representatives from the Forest Service, the U.S. Department of the Interior, the National Park Service, the University of California, the California Academy of Sciences, and a member of the National Academy of Sciences.

With initiating this landscape-level review, pressure was placed on the Regional Forester to stop the planning effort pending study completion. However, the Regional Forester believed that the SNEP review process would not be available within the two-year time frame upon which the FONSI was based. Instead, he offered to open up the planning process to the Sierra Nevada Ecosystem Project Team (SNEP Team) and to share information. Feedback from the SNEP Team at the time indicated that the EIS team was using state-of-the-art modeling tools and approach.

During 1993, Chief of the Forest Service F. Dale Robertson was replaced by Dr. Jack Ward Thomas.

The SNEP Science Team was eventually composed of 18 team members and 19 special consultants. In addition, many other scientists worked closely with team members (107 as authors or coauthors of chapters and reports), some throughout the Project. The Project devoted most of its effort to analyzing existing information rather than conducting new studies or experiments. Its final report to Congress was issued in 1996 (Sierra Nevada Ecosystem Project 1996).

In August 1994, new Regional Forester Lynn Sprague arrived in the Pacific Southwest Region and took over responsibility for the planning effort.

The first Draft EIS was issued in February 1995. However, based on significant public controversy and additional information provided during the review period, a second Draft EIS was released in 1996.

Again, based on release of the SNEP report and controversy raised by the second DEIS, the Secretary of Agriculture chartered a federal advisory committee under the Federal Advisory Committee Act (FACA) in May 1997 to review the revised DEIS. The committee, composed of members from the academic and scientific communities, issued a report in late 1997 criticizing the revised DEIS: the strategy selected was insufficient either as an owl habitat management plan or as a broader ecosystem management plan.

Shortly after the Secretary convened the scientific advisory committee, the U.S. Senate Subcommittee on Forest and Public Land Management and the House Subcommittee on Forests and Forest Health formed a separate scientific review committee to review and evaluate the the revised DEIS. In September 1997, this committee released a draft report finding that the RDEIS had reviewed all relevant information available at the time, and that it had followed appropriate procedures, including adequate modeling techniques and databases. In May 1998 the California Forest EIS Review Committee, as it was called, released its final report affirming its earlier findings.

The Final Environmental Impact Statement and Record of Decision

In response to the Federal Advisory Committee's report to the Secretary of Agriculture on November 13, 1997, Chief of the Forest Service Mike Dombeck instructed the Regional Forester for the Pacific Southwest Region and the Station Director for the Pacific Southwest Research Station via letter to "significantly improve the conservation strategy (for California spotted owls and all forest resources) through strong collaboration with partners and researchers." Chief Dombeck further directed that "The strategy will stand on the solid foundation of the best available science. Our goal is to ensure the ecological sustainability of the entire Sierra Nevada ecosystem and the communities that depend on it"

The Forest Service engaged potential collaborators in discussions and convened an open public meeting with those potential collaborators from federal, state, county and tribal governments in Sacramento, California, on February 26, 1998. Interest was high…but commitments to collaborative planning were weak. On May 1, 1998, the Regional Forester in the Pacific Southwest Region issued a letter of instruction to Forest Supervisors in the Sierra Nevada that identified 4 tasks for "Improving conservation options for national forests in the Sierra Nevada."

Task 1 was the May 1 letter itself that clarified existing guidelines for habitat management and identified a process for reviewing projects that deviated from those guidelines. It also disclosed the key resources at issue in improving conservation options: old forests and their associated species, roadless areas, riparian and aquatic ecosystems, and fire and fuels management. Task 2 was a science review to inform the plan amendment process. Task 3 was the plan amendment process culminating in the FEIS.

Task 4 outlined the broader goals of a long-range conservation framework to be developed in collaboration with other agencies and the public, what is now known as the Sierra Nevada Framework for Conservation and Collaboration. The Framework had two fundamental principles:

1. science-based conservation, i.e., to bring the best available science to bear on understanding challenging problems; and
2. collaborative problem solving, i.e., to work collaboratively with others to design, implement, and monitor conservation policy, programs and actions that will sustain desired environmental, economic and social conditions in the Sierra Nevada to meet the needs of people both now and in the future.

In July 1998 the USDA Forest Service Pacific Southwest Research Station published the Sierra Nevada Science Review (USDA Forest Service 1998b) synthesizing current scientific information concerning issues of urgent priority at the Sierra Nevada range-wide scale. A companion document, the Summary of Existing Management Direction, was released in August 1998 (USDA Forest Service 1998a), summarizing current management direction related to issues identified in the Science Review. These documents provided background information useful to understanding the relationship between existing forest plans, social and economic values, and environmental trends in the Sierra Nevada.

On July 10, 1998, the Regional Foresters of Forest Service Regions 4 and 5 committed to develop a new management direction for national forests in the Sierra Nevada and Modoc Plateau. An extensive public involvement process for this FEIS began in September 1998, prior to issuing the Notice of Intent to amend the Land and Resource Management Plans for national forests in the Sierra Nevada and Modoc Plateau. Meetings and workshops were held throughout the Sierra Nevada and in San Francisco and Los Angeles so that individual citizens, private groups, tribes, elected officials, and public agencies could provide their perspectives to help frame the FEIS's purpose, need, and proposed action. A statewide meeting was held in Davis, California in October. A Sierra Nevada tribal summit was held at Tahoe City, California in September, and meetings

with several American Indian tribes were held in Clovis, Bishop, Placerville, Susanville, Big Pine, and Oroville, California. Tribal members also attended several of the public meetings. This collaborative effort—completed prior to developing and analyzing alternatives—was important in identifying key problem areas facing the Sierra Nevada. Further, the USDI Fish and Wildlife Service (FWS), U.S. Environmental Protection Agency, and other state and federal agencies were active participants in developing the FEIS. FWS personnel were also members of the interdisciplinary team.

On November 20, 1998, using information and ideas gathered during the preceding 10 months, the Pacific Southwest Region and Intermountain Region published a Notice of Intent to prepare an Environmental Impact Statement in the Federal Register, beginning a 60-day formal public scoping period. During the scoping period, additional public information meetings and workshops were held, and consultations with Native American tribes also continued. About 3,500 comments were received and analyzed to help develop ways to improve national forest management. Significant issues were identified from these comments and used to develop alternatives.

During 1998, Regional Forester Lynn Sprague was replaced by Bradley E. Powell.

Figure 11. Stakeholder Issues

Ecosystem Management:
Some advocated a preservation approach, essentially letting nature decide future ecosystem conditions and their associated societal benefits. Others believed that more active management is essential to achieve desired environmental conditions that best meet people's needs, and recommended that timber harvesting and prescribed fire be used to maintain healthy forest conditions. Still others advocated a balance of land conservation strategies where some lands are protected from human management and other lands are managed to achieve desired environmental conditions and associated social benefits.

Old Forest Ecosystems:
A significant debate centered on the amount and distribution of old forest ecosystems needed to sustain viable populations of old-forest-associated species. In addition, both the public and scientific communities had differing views about appropriate practices and methods to increase and perpetuate old forests.

Riparian and Aquatic Ecosystem Health:
There was disagreement over the appropriate level of management activities and types of uses in aquatic and riparian areas. One view was that management actions have the potential to degrade aquatic and riparian ecosystems. Another was that aquatic and riparian ecosystem health can best be maintained and enhanced through active management.

Fire and Fuels:
There were differing views regarding the type, rate, and intensity of actions that should be taken to reduce fuel hazards. Among those that believed management actions should be taken, there was disagreement over the method (e.g. prescribed fire versus mechanical treatment) and strategy (e.g. linear fuelbreaks versus strategic area treatments), treatment priorities, and where to emphasize treatments.

Habitat for Threatened, Endangered, and Sensitive Species:
Some advocated protection from both human interventions and nature's catastrophic events, e.g. wildfire, while others advocated judicious management to encourage desired habitat conditions and reduce the risk of losses to catastrophic events.

Lower Westside Hardwoods:
Active management advocated wanted to maintain and enhance hardwood forests through mechanical methods and prescribed fire. Preservation advocates wanted very little active management.

Issues

Comments received during the public involvement process revealed important issues and/or public concerns, which then became influential considerations in designing and evaluating the alternatives. Issues were also identified by reviewing published scientific,

administrative, and policy documents. With respect to the current study the key issues are: ecosystem management; old forest ecosystems; riparian and aquatic ecosystem health; fire and fuels; habitat for threatened, endangered and sensitive species; and lower Westside hardwoods (see Figure 11).

Alternatives

Similarities

The Sierra Nevada Forest Plan Amendment Project addressed five problem areas:

- old forest ecosystems and associated species;
- aquatic, riparian, and meadow ecosystems and associated species;
- fire and fuels management;
- noxious weeds; and
- lower westside hardwood ecosystems.

Each action alternative was designed around a management theme which set the vision for the alternative and responded to one or more of the significant issues. Each action alternative proposed management strategies, consistent with its alternative's theme, to address the five problem areas.

All action alternatives:

- protected large trees, typically associated with old forest conditions, across the Sierra Nevada national forests;
- had an aquatic management strategy (AMS) that incorporated current scientific knowledge and ensured that Californians would continue to enjoy the water quality and quantity to which they were accustomed;
- treated fuels to reduce losses in the urban–wildland intermix zone, where human health and safety concerns dominate;
- increased attention to threats posed by the unchecked spread of noxious weeds and put in place a means to arrest their spread;
- protected lower westside hardwoods and enhanced conditions for hardwood species;
- used landscape analysis to provide a context for managing whole ecosystems and to better understand how landscapes and watersheds function before projects are planned; and
- used an adaptive management process to adjust management direction for future events, changing knowledge, or dynamic social views.

Differences

The alternatives varied in how old forest conditions were identified and managed—from small patches to larger watersheds to even larger landscapes across Sierra Nevada national forests—to provide wildlife habitat, increase biological diversity, and meet people's needs for recreational access and clean water. In addition, the alternatives differed in methods used to designate riparian areas, and in management activities allowed in these areas.

For many citizens, the most important difference between alternatives was the extent to which fire and fuel treatments were carried out. Fuel treatments to reduce losses in the urban–wildland intermix zone were common to all alternatives; the alternatives vary in the degree to which wildfire losses and intensity were affected in broader forested areas. There were different tradeoffs related to environmental risks from wildfire and other natural disturbances, risks to the environment from fuel treatments, and costs and benefits to both the environment and its ability to meet human needs. Uncertainty about the consequences associated with implementing or not implementing fuel treatments further differentiated the alternatives.

Each alternative therefore incorporated a strategy for adaptive management—learning from experience to reduce uncertainties caused by a lack of knowledge—but each was differently configured to work in concert with or to anticipate the very large forces of natural succession, drought, and wildland fire that could easily dwarf humans' best efforts to conserve their national forests and achieve both the environmental and social benefits of conservation.

Figure 12. Themes of the Alternatives

Alternative 1's Theme: Continue management in existing national forest land and resource management plans.

Alternative 2's Theme: Establish large reserves where management activities are very limited.

Alternative 3's Theme: Actively manage to restore ecosystems. Use local analysis and collaboration.

Alternative 4's Theme: Develop ecosystems that are resilient to large-scale, severe disturbances.

Alternative 5's Theme: Preserve existing undisturbed areas and restore others to achieve ecological goals. Limit impacts from active management through range-wide management standards and guidelines.

Alternative 6's Theme: Integrate desired conditions for old forest and hardwood ecosystems with fire and fuels management goals. Reintroduce fire into Sierra Nevada forest ecosystems.

Alternative 7's Theme: Actively manage entire landscapes to establish and maintain a mosaic of forest conditions approximating patterns expected under natural conditions.

Alternative 8's Theme: Manage sensitive wildlife habitat cautiously. Develop new information to reduce uncertainty about the effects of management on sensitive species.

Modified Alternative 8's Theme: Manage sensitive wildlife habitat cautiously. Provide for species conservation while addressing needs to reduce the threat of fire to human communities.

Themes of the Alternatives

A full discussion of the alternatives is available in the Final Environmental Impact Statement (USDA Forest Service 2001a) and will not be covered here. For our purposes, we list each alternative's theme in Figure 12. The alternatives were developed following extensive discussion with other agencies and with stakeholders. Specifically, Alternative 2 was built upon suggestions from the Sierra Club; Alternative 3 was based on information provided by the Association of Forest Service Employees for Environmental Ethics; Alternative 4 was based on suggestions from the California Forestry Association (the timber industry); Alternative 5 was offered by the Sierra Nevada Forest Protection Campaign (an alliance of conservation and environmental organizations); Alternative 6 reflects input from Forest Service managers; Alternative 7 incorporated ideas from the Modoc County Land Use Committee; Alternative 8 was based on suggestions from the USDI Fish and Wildlife Service; and

Modified Alternative 8 resulted from additional discussions with the Fish and Wildlife Service.

Record of Decision

The Forest Service received 47,000 comments on the Draft Environmental Impact Statement, and addressed them in the Final Environmental Impact Statement (USDA Forest Service 2001a) and Record of Decision (ROD) (USDA Forest Service 2001b). The ROD and accompanying Standards and Guides were signed on January 12, 2001, by the Regional Forester of the Pacific Southwest Region, implementing the preferred alternative: Modified Alternative 8. This alternative was based in applying the precautionary principle to deal with high levels of uncertainty, and relied heavily on using prescribed fire and limited use of mechanical removal for meeting fuels reduction objectives. It required a high degree of canopy coverage in existing forests. The precautionary principle was also evident in the prescriptive and restrictive Standard and Guides for implementing the decision. Furthermore, the decision called for a strategy of adaptive management, including monitoring and experimenting, to deal with uncertainty over the long term. The ROD described adaptive management as "a continuous process of action-based planning, monitoring, research, evaluation, and adjustment, with the objective of improving implementation to achieve desired management goals and objectives" (USDA Forest Service 2001b). The ROD updated the Forest Plans of the 11 national forests in the Sierra Nevada and Modoc Plateau.

The Controversy Continued

In April 2001 the National Association of Forest Service Retirees (2001) issued a report critical of the decision. Among the most serious concerns were:

1. the preferred alternative was less responsive to the stated goals than other alternatives considered;
2. it would fail to adequately protect existing old growth and adjacent communities from catastrophic wildfire due to relying on prescribed burning as the tool of choice for fuels management;
3. it would result in reduced levels of late-seral forests in the future due to lack of regeneration resulting from the high level of canopy coverage;
4. existing and expected budgets would not permit fully implementing planned fuels treatments;
5. requirements of the Clean Air Act, weather, and fuels conditions would severely limit prescribed burning; and
6. significant restrictions and requirements included in the Standards and Guides would conflict with the fuels management strategy.

During the same month, the Forest Service received 276 appeals, 234 of which were received in a timely manner and, therefore, 42 were not considered in the appeal decision. Eighteen requests to intervene were filed by interested persons, potentially affected persons, or organizations. This was the largest number of appeals received by the Forest

Service on a specific project. Appeals of plan decisions are made to the next-highest organizational level, in this case to the Chief of the Forest Service.

In January 2001, President Clinton was replaced by President George W. Bush. In April 2001, Dale Bosworth succeeded Mike Dombeck as Chief (and reviewing official). On November 5, 2001 the Chief named Jack Blackwell to succedd Brad Powell as Regional Forester..

On November 16, 2001, the Chief issued his decision affirming the Sierra Nevada Forest Plan Amendment (SNFPA) decision, but directed the Regional Forester to review three elements of the decision along with concerns raised in the appeals. During the review, the decision remained in effect and the projects approved under the plan were implemented. The Chief directed the Regional Forester to consider the continued high level of recent fire activity in California, the relationship between the SNFPA and national firefighting efforts, and the relationship between SNFPA and the Herger-Feinstein Quincy Library Group Forest Recovery Act (HFQLG). The Regional Forester also requested the that the review consider the impacts of 2001 SNFPA decision on recreation, livestock grazing, and local communities.

Reconsidering the Decision

On December 31, 2001, the Regional Forester of the Southwest Region appointed a team to review the SNFPA fuels treatments, consistency of SNFPA and the National Fire Plan, and compatibility of SNFPA with HFQLG. The team was also asked to review the other three issues identified in the Chief's appeal decision (impacts on recreation, grazing and local communities). The Regional Forester asked the Team to focus on developing flexible solutions to the plan to improve local decision-making capabilities, while meeting obligations under all applicable environmental laws (Blackwell 2001). The review consisted of a five-step process: (1) identify issues, (2) validate the issues, (3) develop and evaluate options, (4) provide recommendations to the Regional Forester, and (5) issue decision (USDA Forest Service 2002b).

In August 2002, the Regional Forester wrote to district rangers in the affected national forests and asked them to respond to a number of specific questions (Blackwell 2002):

1. In FY 2001 and FY 2002, have you implemented any vegetation management projects (fuels or timber) under the standards and quidelines of the Framework? If not, why not? If yes, what has been your experience? Are there non-Framework barriers (e.g., budget, staffing & skills, air quality, NEPA…) that hinder your fuels treatment program?
2. Are the standards and quidelines (S&Gs) in the Framework compatible with implementation of the National Fire Plan? If not, which S&Gs are in conflict and how would you change them?
3. What were your targets for fuel reduction treatments and what have you been able to accomplish by type of treatment around communities, both with S&PF (State and Private Forestry appropriated funds) and our own work on national forest lands? Do the Framework S&Gs give enough direction and

flexibility for you to accomplish your fuels treatment program? If not, which standards and guidelines need to be changed?

4. Do you feel Modified Alternative 8 provides an appropriate balance among ecological, social and economic values as it strives to protect wildlife habitat and reduce fuels? If so, why? The Chief upheld Modified Alternative 8 but directed me during this review to look at other alternatives, especially those that have better outcomes for wildlife and fuels (e.g., Alternatives 4, 6, and 7). Do you feel that any of these other alternatives provides a better balance among ecological, social and economic values? Why, or why not?
5. The Review Team posted its observations about S&Gs and other areas of the Framework that are problems for implementation. Please look at these and let me know if you think the Review Team is on the right track? Are we missing anything?

Thirty-three district rangers and one planning officer prepared written responses, which were summarized by three of the district rangers for presentation to the Regional Forester (Keil, Martin et al. 2002). Of the 25 district rangers that responded to question 1, 8 had to revise existing NEPA approved projects to the fit the new S&Gs, 4 only implemented pre-Framework projects, and the remaining 3 did not implement projects under the framework during FY 2001 and FY 2002.

For question 2, 7 out of 10 respondents found the tree-cutting diameter limits too restrictive, 13 out of 17 respondents found the canopy cover limits too restrictive, and 8 out of 14 respondents found that requirements for surveying and monitoring were excessive. Eleven out of 12 identified problems with reliance on prescribed burning as the preferred method for fuels management. (Not all rangers responded to each question, and some responded more than once to a question.) Problems included fuel loading too high for prescribed burning at first entry (5 respondents), reliance on prescribed burning as the primary method (4 respondents), and difficulty in keeping prescribed burns out of the protected areas. Others saw problems with limited operating periods, such as burning season length, restrictions on the number of mechanical treatments per decade, high levels of dead tree (snags) retention, and managing fuels in the wildland–urban interface.

For the portion of question 2, "If changes are necessary, what do you recommend?", the district rangers suggested more reliance on mechanical treatments and more management flexibility to deal with local situations. With regard to non-Framework barriers (part of question 1), 16 out of 19 respondents said that budget uncertainties and priority shifts were a problem; 16 out of 17 respondents noted lack of skilled staffing as an issue.

To refine issues and options, the Management Review Team held numerous meetings with federal and state agency representatives, the scientific community, and stakeholders; and conducted a number of field trips to look at issues and increase understanding. Finally, the Regional Forester requested that a team of scientists—the George Mason University and the Ohio State University team (Drs. Larry Walters, Peter Balint, Anand Desai, and Ron Stewart)—to review how the Forest Service dealt with risk and uncertainty in the SNFPA decision, and how it should be dealt with in reviewing the

decision. The Risk and Uncertainty Panel met with stakeholders in two meetings, and with key Forest Service and state and federal agency personnel, to provide information on risk and uncertainty and to administer survey instruments on stakeholder preferences.

On February 14, 2003, the Management Review Team issued a draft "SNFPA Management Review and Recommendations" (USDA Forest Service 2003) revising the set of vegetation management rules, combined with existing land allocation desired condition statements, to increase the fuels reduction strategy's effectiveness while protecting critical wildlife habitat. They further recommended more aggressively treating fuels to meet the requirements of the National Fire Plan. Applying more effective vegetation management treatments, conducting forest gap regeneration on a small part of the landscape, and applying HFQLG ROD land allocations and S&Gs in the area covered by the HFQLG Act were also proposed. Finally, greater flexibility in administering grazing permits and clarifying and adjusting rules on recreational activities were recommended.

In March 2003, the Risk and Uncertainty Panel issued a draft report to the Regional Forester and Review Team, defining the nature of risk and uncertainty and reviewing several approaches to dealing with these issues: the precautionary principle, adaptive management and participatory processes. The team further characterized the Sierra Nevada planning effort as a wicked problem.

Finally, on June 5, 2003, the Regional Forester issued a press release announcing the availability of a 372-page Draft Supplemental Environmental Impact Statement (DSEIS). The DEIS incorporates information from the Review Team, the Risk and Uncertainty Panel, scientists, state and federal agencies, and stakeholders. It documents new information obtained since the Framework decision was released in 2001, and analyzes the effects of 10 alternatives, 7 of which are from the original SNFPA EIS. These seven alternatives are only briefly described in the DSEIS, but are available in detail in the original FEIS. However, because the other alternatives had been presented fully in the original EIS, the focus in the DSEIS was only on the first three alternatives, designated S1, S2 and S3.

Alternative S1 would continue the current Framework direction. Alternative S3 would implement fuels treatments only in the areas closest to communities, pending the outcome of studies of how owls respond to fuel reduction projects.

S2, the preferred alternative, incorporates the recommendations of the Review Team, permitting cutting trees up to 30 inches in diameter at breast height (dbh) under certain conditions. Cutting larger trees would offset some of the costs of removing many more small-diameter trees and allowing more area to be treated. The focus would initially be within the wildland–urban interface zone. The preferred alternative also modifies some of the detailed and prescriptive S&Gs that hindered achieving fuels management objectives. This alternative would give managers more local discretion to develop land use practices that balance wildlife habitat protection with other uses. Finally, the

proposal implements the HFQLG pilot project to the fullest extent possible consistent with federal law. A 90-day comment period on the DSEIS closed September 12, 2003.

Finally, on January 22, 2004, the Regional Forester issued a Record of Decision and Final Supplemental Environmental Impact Statement adopting the preferred alternative (USDA Forest Service 2004b). He also announced a campaign to implement the decision called "Forests With A Future" (USDA Forest Service 2004a).

A BRIDGE TOO FAR, A ROAD TOO LONG?

The Sierra Nevada Forest Plan Amendment process began with a review of the 1992 strategy for managing California spotted owl habitat, and continued into 2004. This protracted planning effort spanned three Presidents (George H. W. Bush, William J. Clinton, and George W. Bush), four Regional Foresters (Ron Stewart, Lynn Sprague, Brad Powell, and Jack Blackwell) and four Chiefs of the Forest Service (F. Dale Robertson, Jack Ward Thomas, Mike Dombeck, and Dale Bosworth). Throughout numerous public involvement sessions, public stakeholders regularly engaged in the process have dwindled from more than 200 at the beginning to about 50 to 60 today.

Thus, while a comprehensive analysis and public participation process was essential, the long time period required to reach a decision was not without cost, both monetarily and stakeholder engagement. Ultimately, decisions of this nature require a significant stakeholder trust in the decision maker. This, in turn requires that the principal partners in the effort, the agency leadership and stakeholders, develop a working relationship. The turnover in key agency personnel, at both the regional and national level, did not contribute to an atmosphere of trust-building.

IS THE SIERRA NEVADA FOREST PLAN AMENDMENT PROCESS A WICKED PROBLEM?

As this review of the Sierra Nevada Forest Plan Amendment process's administrative, ecological, and social contexts reveals, this decision problem is filled with risk and uncertainty. Table 1 (in Chapter 2) summarizes some of these uncertainties in the framework of the nature of the decision problem described earlier (Figure 10). This obviously simplified description of the problem is further complicated by the scale of the landscape under consideration (11.6 million acres) and the number of people impacted by the decision.

Table 4 compares the decision problem in the Sierra Nevada Forest Plan Amendment situation point-for-point with the characteristics of wicked problems described in Allen and Gould (1986) and Salwasser (2002).

Table 4. Wicked Problems vs. The Sierra Nevada Case

Characteristics of Wicked Problems	The Sierra Nevada Case
The definition of the problem is in the "eye of the beholder"; that is, each stakeholder defines the problem differently and therefore there is no single correct formulation of the problem. Stakeholders are fragmented.	The stakeholders in the Sierra Nevada case represent a wide variety of environmental, industrial, and community interests. Their broad ranges were represented in our small survey sample. While most were in agreement that fuels management and protecting old-growth-dependent species were important goals, there was little agreement over approach(es) to achieve them. This lack of agreement reflects different values and perceptions of risk. Successful outcomes are defined differently by the various interests.
Outcomes are not scientifically predictable. Scientific messiness and uncertainty.	In this chapter we have painted a picture of the Sierra Nevada's diverse ecosystems. While much is known about the behavior of these systems' more common —and economically valuable— components, especially in the short term, much remains unknown or unknowable. State-of-knowledge models used in assessing long-term impacts of the various alternatives seem to provide an unwarranted level of certainty; however, the confidence intervals around the predicted outcomes, especially in the distant future, are unknown. Further, while stochastic events can be modeled, their actual frequency and intensity can not be accurately predicted with current technology.
The decision maker cannot know when all feasible and desirable solutions have been explored.	The potential number of alternatives theoretically and feasibly possible is quite large. Therefore, analysts generally chose a small number from the larger set that represent a range of possibilities (in the case of the Sierra Nevada, nine alternatives to model and display. This is thought to be necessary for public understanding; however, it can also imply that these chosen ones are the only possibilities. In the absence of good information on stakeholder preferences and values, it would be difficult to know when all feasible and desirable solutions have been explored.
The resources of ecosystems, communities of interest, funds, organizational capabilities, etc., combine with stakeholder demands in idiosyncratic ways; therefore, any solution is likely to be "one-shot" and unique.	Some elements of the Sierra Nevada case are common to other decision problems facing the USDA Forest Service. However, the specific combination of ecosystems, including their status and interacting species, community demographics, agency capabilities and limitations, funding opportunities, and other factors affecting the decision over an area the size of the Sierra Nevada, are unique.

Characteristics of Wicked Problems	The Sierra Nevada Case
Solutions are generally better or worse, rather than true or false.	Given the range of stakeholder preferences and values, the wide range of potential solutions, and the uncertainty of outcomes, it will be difficult to find a perfect solution in the Sierra Nevada case. Each solution meets certain ecological and social needs, but not all needs. Nor will any solution satisfy all stakeholders. Further, given the potential for scientific information and societal values to change over the multicentury life of a forest ecosystem, it is unlikely that today's solution—multigenerational at its most ideal—will hold for the long term.

Based on the risks and uncertainties associated with all aspects of the decision framework, and the lack of a clear consensus on public values and perceptions of risk, it is our firm belief that the Sierra Nevada planning effort is a classic wicked problem. Therefore, there is no single correct response, only some responses that are better—or more satisfying—than others. In planning and forest management, the Pacific Southwest Region must cope with the complexities and ambiguities associated with wicked problems. As later chapters reveal, we recommend adaptive collaborative management as the best decision-making process.

CHAPTER 5. RESPONSES TO UNCERTAINTY: THE PRECAUTIONARY PRINCIPLE AND RELATED APPROACHES

INTRODUCTION

Making decisions following the precepts of the precautionary principle (PP) has been proposed as means to protect human health and the environment under conditions of scientific uncertainty (e.g., Cameron and Aboucher 1991; Dethlefsen 1993; Raffensperger and Tickner 1999; deFur and Kaszuba 2002). However, the precautionary approach has also been criticized as ambiguous, unscientific, and of limited utility as a concrete guide to policymaking (e.g.Bodansky 1991; Manson 2002; Pielke 2002; Sunstein 2003)

Controversy over this principle's effectiveness necessitates that the PP be more carefully defined, interpreted, and evaluated. In the particular case of the Sierra Nevada national forests, for example, precautionary thinking played a significant role in shaping the January 2001 Sierra Nevada Forest Plan Amendment (SNFPA) Record of Decision (ROD). In that document, the Regional Forester accepted the notion that new forest management practices should not be undertaken unless they could be shown not to pose a threat to California spotted owls and their habitat. Yet, the ROD was later reexamined and opened to revision in part because forest managers responsible for its implementation reported that the decision's prescriptive, precautionary standards and guidelines made it difficult to achieve stated goals. According to Forest Service personnel, therefore, language intended to protect owl populations and other ecological characteristics of the forests were found in practice to interfere with conservation efforts (USDA Forest Service 2003). Moreover, former Chief of the Forest Service Jack Ward Thomas included similar findings in a report on the progress of the Northwest Forest Plan (NWFP) for managing national forests in northern California (Thomas 2003b). In his review of the NWFP, Thomas concluded that applying the PP had increased the risk of fire in the region, contributed to economic losses in local communities, and dampened innovation in forest management. Thus, both in general and in the particular case of the SNFPA decision process, the PP has been portrayed at the same time as an essential component of, and as an obstacle to, rational environmental policy making. A central concern is that relying on the PP for large-scale management decisions—particularly for wicked problems—may allow society to avoid the targeted risk, while leading to other outcomes that are at least as undesirable.

This chapter begins by exploring the controversy over the precautionary principle in detail. We then discuss three alternative responses to uncertainty in environmental decision making that are related to the PP and adaptive management:

- safe minimum standards (SMS),
- critical natural capital (CNC), and
- best management practices (BMP).

We emphasize the PP in our discussion because we believe this principle has significantly influenced both public attitudes and forest management decision making. For each of these four approaches we review the types of uncertainty addressed, offer working definitions of key terms, discuss the approach's evolution and current usage, consider its strengths and weaknesses, and consider its relevance for the SNFPA decision process.

To summarize, we argue that although the PP has clear strengths, its weaknesses as a decision-making tool outweigh its positive attributes. Moreover, we find that the concept has become highly politicized, further undermining its usefulness. We suggest that a strategy of adaptive collaborative management is likely to be a more practical and effective response to uncertainty in environmental management. As discussed in Chapter 7, we believe this approach has the best chance to incorporate the strengths of the precautionary principle, adaptive management, and public participation, while avoiding their limitations.

PRECAUTIONARY PRINCIPLE: CONCEPTS, DEFINITIONS, AND HISTORY

The precautionary principle has yet to be standardized in practice or in the literature (O'Riordan and Jordan 1995; Manson 2002). Judged by the implications for policy making, however, formulations of the PP can be seen to fall along a continuum from weak to strong. Principle 15 of the Rio Declaration of 1992, for example, includes a relatively weak version: lack of unassailable scientific proof that an activity causes harm should not be used to justify permitting the activity to continue unregulated (United Nations 1992b). Yet at the same time the document dilutes the argument's force by suggesting that precautionary measures to protect the environment must meet cost-effectiveness standards and that countries can only be expected to implement such measures "according to their capabilities."

A strong version of the PP, perhaps the strongest possible, was included in the so-called Delaney Clause of the U.S. Federal Food Drug and Cosmetic Act (FFDCA) from 1958 until 1996 (U.S. Congress 1958). Language in the Delaney Clause prohibited any use as a food additive of any substance that had been shown in any amount to cause cancer in animals or humans. Moreover, language in the statute forbade applying new, presumably more accurate scientific techniques that might later show no harm from the additive below some threshold. Nor did the clause permit using a suspect substance even if the probability of an adverse health effect was vanishingly small and if, at the same time, significant known benefits would result from its use. Although the PP had yet to be named as such in 1958, the Delaney Clause's language is clearly a strong early example of precautionary policy making.

Other formulations of the PP fall along this continuum from weak to strong (Jordan and O'Riordan 1999):

- Folk wisdom: "Better safe than sorry." (Weak: includes no mandate for action.)

- Hippocrates, c. 400 BCE (paraphrased, see von Staden 1996): "Above all, do no harm." (Strong: asserts that avoiding harm supercedes all other objectives, regardless of the consequences.)
- FFDCA Delaney Clause (U.S. Congress 1958): No substance can be used as a food additive in any amount if "found to induce cancer when ingested by man or animal, or if found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal." (Strong: bans use despite uncertainty of an effect in humans.)
- United Nations World Charter for Nature(1982): "[When] potential adverse effects [of activities] are not fully understood, the activities should not proceed." (Strong: requires a moratorium in the case of uncertainty.)
- London Declaration (Second International Conference on the Protection of the North Sea 1987): "Accepting that, in order to protect the North Sea from possibly damaging effects of the most dangerous substances, a precautionary approach is necessary which may require action to control inputs of such substances even before a causal link has been established by absolutely clear scientific evidence." (Weak: includes qualifying language such as "*may* require action" and "before…*absolutely* clear…evidence.")
- Principle 15 of the Rio Declaration (United Nations 1992b): "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." (Weak: includes qualifying language such as "according to their *capabilities*" and "…postponing *cost-effective* measures.")
- International Joint Commission (1994) : "All persistent toxic substances are dangerous to the environment, deleterious to the human condition, and can no longer be tolerated in the ecosystem, whether or not unassailable scientific proof of acute or chronic damage is universally accepted." (Strong: bans use despite uncertainty of effects.)
- Wingspread Declaration on the Precautionary Principle (Raffensperger and Tickner 1999): "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not established scientifically. In this context the proponent of the activity, rather than the public, should bear the burden of proof." (First sentence weak: uses qualifying language such as "*should*" and "*some*"; second sentence strong: unequivocally shifts the burden of proof on risk vs. safety onto the advocate of the potentially damaging activity.)

Defining Terms

The core idea underlying the PP contains three components: potential harm from a proposed activity, uncertainty regarding cause and effect and/or probability of effect, and proposed remedies (Manson 2002). Thus, for purposes of discussion, the PP can be stated generically as:

Under conditions of uncertainty, activities that may cause harm should be regulated.

In this basic formulation, "uncertainty" generally refers to *scientific uncertainty*, but may also refer to *scientific ignorance* and/or *uncertainty regarding values*. In the context of *scientific uncertainty*, the phrase "conditions of uncertainty" refers to a state of affairs in which

- causal links (if any) between a proposed activity and the harm that may (or may not) result from that activity are not clearly established or understood; and
- the probability of harm occurring given the activity cannot be reliably estimated, or is estimated to be low.

Regarding the second point: If the probability of harm occurring is uncertain but can reasonably be estimated as moderate to high, the justification for regulatory action can be considered preventive, rather than precautionary. This distinction recognizes that preventive regulations in the case of strongly suspected but not yet conclusively proven hazardous effects (e.g., stricter limits for arsenic in drinking water) are likely to be significantly less controversial than precautionary regulations in the case of suspected potential harms with considerably weaker supporting scientific evidence (e.g., bans on food crops genetically modified to repel agricultural pests).

In the context of *scientific ignorance* in the generic expression of the PP presented above, the phrase "conditions of uncertainty" refers to a state of affairs in which science cannot predict or assess the probability of potential harms that are unforeseeable given current knowledge (e.g., ozone depletion from CFCs at the time of their introduction in the 1930s). Because it is impossible to prove a negative (that no future environmental damage will occur from unforeseen and unforeseeable effects of a given activity), this state of affairs can never be shown not to exist. In other words, any activity holds some potential for adverse consequences, and entirely risk-averse persons or societies would be unable to go forward with any new technology or new environmental management regimes.

In the context of *uncertainty regarding values*, "conditions of uncertainty" refers to a state of affairs in which normative judgments among stakeholders—regarding potential harms related to the activity, regarding the activity itself, or regarding risk tolerance generally—are unclear, unsettled, or in flux. In such cases, it is impossible to avoid the risk that some stakeholders at some point in the future may find the outcome of a particular action (or inaction) ethically unacceptable.

In the generic statement of the PP presented above, the term "activities" refers to actions that have some (uncertain, perhaps very small) probability of causing harm. Unavoidably, this category will also include activities that, if actually undertaken, would have:

- no effects,
- positive effects only,

- both positive and negative effects, but with positive effects outweighing negative effects,
- both positive and negative effects, but with negative effects outweighing positive effects, or
- negative effects only.

An additional complication is that although the term "activities" typically refers to actions (e.g., introducing genetically modified organisms into the environment, introducing excess greenhouse gases into the atmosphere, etc.), it may also refer to "inactions," or choices not to act (e.g., continuing with business as usual in fossil fuel use, not reducing fuel loads in national forests, etc.).

In the context of the generic statement of the PP, the term "harm" in the phrase "activities that may cause harm" generally refers to serious harm, including, but not limited to, catastrophic or irreversible damage. In debates over environmental policy in particular, "harm" generally refers to threats to human heath or to ecological systems, including biological diversity.

In strong formulations of the PP, the term "regulated" signifies that the activity in question is banned or subject to a moratorium. In weaker versions, "regulated" may mean that the activity is subject to closer scrutiny and/or restrictions in its application. Weaker versions of the PP may also include provisions for investing in further research to reduce uncertainty regarding the potentially dangerous activity, under the assumption that if uncertainty can be reduced enough, conventional decision rules may then apply. In stronger versions, further research may be discouraged or discounted in advance.

History

In the late 1960s and early 1970s, both in the United States and in Europe, the combination of increasing incomes and increasingly obvious levels of pollution of air, land, and water led to a political shift in the electorate in favor of stricter environmental protection. This trend was particularly powerful in the United States (Landy, Roberts et al. 1994; Portney and Stavins 2000). During President Nixon's first term in office, for example, polling data indicated that the environment was in some periods the public's top policy concern (Wicker 1995). Although the president was not particularly sympathetic to environmental concerns (Mann and Plummer 1996), the administration responded by establishing the Environmental Protection Agency in 1970 and by supporting a series of major new environmental laws over the next several years, many of which contained overtly precautionary language. Over time, however, attitudes in the United States and Europe regarding the PP have diverged. In Europe, and in the United Nations and other multilateral institutions, precautionary thinking relating to the environment has strengthened, while in the United States there has been a trend—certainly with many dissenters—toward greater recognition of cost-benefit and cost-effectiveness considerations (Vig and Kraft 2003).

Europe and the United Nations

In Europe, the PP can be traced to "*Vorsorgeprinzip*," a concept developed in Germany in the early 1970s (von Moltke 1988; O'Riordan and Jordan 1995). The term, which translates literally as "principle of advance caring," was first applied in response to observed deteriorations in the health of German forests. Acid rain associated with sulfur and nitrogen emissions from industrial, commercial, and transportation sources was the suspected culprit, but science could not provide firm evidence of cause and effect. Despite this scientific uncertainty, the German government instituted regulations to reduce power plant emissions.

After evolving into a key component of German environmental law, the concept of precautionary action has gradually gained wider acceptance across Europe and has been incorporated into various international treaties, conventions, and declarations (Dethlefsen 1993; Raffensperger and Tickner 1999). Several of these are cited above in the list of alternate statements of the PP. Others include the Maastricht Treaty strengthening political and economic union in Europe (European Union 1994), the Barcelona Convention to protect the Mediterranean Sea (United Nations 1995), the Bergen Declaration on energy use and the Baltic Sea (Council of Baltic Sea States 1997), and the Cartagena Protocol on Biosafety (United Nations 2000).

The United Nations Framework Convention on Climate Change (UNFCCC), commonly referred to as the Kyoto Protocol, includes language similar to that found in many of these international agreements:

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. (United Nations 1992a, Article 3, Principle 3).

This formulation includes the three central components of the PP: "lack of…scientific certainty"; potential "serious or irreversible" harms; and a call for "precautionary measures" in response. As noted in other UN or multilateral documents, however, the UNFCCC statement also includes language that mitigates the force of the PP, such as "should take…measures" (implying less than an absolute mandate), "lack of full scientific certainty" (implying that some reasonable scientific evidence of harm is required), and "cost-effective" (implying that the PP does not entirely trump cost-benefit and risk analysis).

The United States

In comparison with European and UN institutions, the United States, particularly from the early 1980s on, has been less sympathetic to the PP. Indeed, there has been considerable resistance to the idea both in Congress and the executive branch. The

divergence of European and U.S. views is exemplified in ongoing, sometimes acrimonious debates over genetically modified organisms (GMOs) and global climate change.

Genetically modified crops and other agricultural products are used on a commercial scale in the United States, and genetically modified food products are widely sold in stores without labeling and without any broad public resistance. Yet, in Europe, there is widespread, vocal, and often vehement opposition to their use. The dispute has reached the World Trade Organization, with the United States arguing that European bans on importing unlabeled GMOs represents an unfair trade constraint, and the Europeans asserting, in turn, that these products' safety has not been demonstrated. Thus, the U.S. position regarding GMOs is that opponents need to show proof of harm before regulations are instituted, while the European position is that proponents of the technology need to show proof of safety before regulations are lifted.

On global climate change, European governments (with widespread public support) ratified and adopted the Kyoto Protocol, a treaty requiring reductions in greenhouse gas emissions to reduce the threat of dangerous changes to the global climate. Although the United States government signed the protocol in 1997, the U.S. Senate almost immediately voted overwhelmingly not to consider ratification. In 2001, the Bush administration openly disavowed the treaty.

The different responses mirror divergent attitudes towards the precautionary principle. The United States government's position is that without proof of risk, economically disruptive precautionary measures are not justified, thereby placing the burden of proof of harm on those who would regulate greenhouse gas emissions. European nations argue, in contrast, that scientific uncertainty should not be used to justify postponing measures to reduce threats of climate change, thus shifting the burden of proof of safety to those who advocate business as usual.

As mentioned earlier, however, many major, ground-breaking U.S. health, safety, and environmental statutes adopted in the 1970s included precautionary ideas, and this provided support for the spread of the PP in Europe and elsewhere (Jordan and O'Riordan 1999). The National Environmental Policy Act, for example, requires that before any proposed government action that may harm the environment can be implemented, environmental impact assessments must be completed and alternatives considered. The Occupational Safety and Health Act requires employers to provide a safe work environment, including implementing precautionary actions to limit workplace exposure to substances suspected of being health risks. The Food and Drug Administration enforces various laws requiring new pharmaceuticals to pass rigorous safety tests before they can be marketed to the public. The Clean Air Act, the Clean Water Act, and the Endangered Species Act also include precautionary language requiring "margins of safety" in health and environmental protection, and in many cases imposing explicit restrictions on using cost-benefit analyses to evaluate protective regulations (Fiorino 1995).

In addition, the President's Council on Sustainable Development, active from 1993 to 1999, expressed open support for the precautionary principle, stating: "Even in the face of scientific uncertainty, society should take reasonable actions to avert risks where the potential harm to human health or the environment is thought to be serious or irreparable" (President's Council on Sustainable Development 1996). Moreover, as seen in policy debates over complex environmental issues in the United States, including the SNFPA case, precautionary thinking influences public opinion and agency decision making even when the PP is not explicitly referenced.

In sum, the overall impact of the PP on environmental policymaking in the United States has been moderate. While precautionary thinking significantly shaped the design of major environmental laws passed in the early 1970s, powerful public and private sector forces have openly worked to reduce its influence in recent decades. In Europe and in multilateral institutions, on the other hand, the PP's influence has increased and has now been widely accepted, at least rhetorically, as a foundation for heath and environmental policies.

PRECAUTIONARY PRINCIPLE: STRENGTHS AND WEAKNESSES, AND PROPOSED IMPROVEMENTS

To clarify the PP's strengths and weaknesses, this section reviews arguments for and against the approach. We then briefly discuss modifications that have been proposed to strengthen or adapt the PP in response to criticisms.

Strengths

As presented by proponents (e.g., Raffensperger and Tickner 1999), the key strengths of the PP are that it:

1. promotes a prudent, cautious, go-slow, safety-first attitude toward activities that may pose significant risks to human health and the environment;
2. highlights risks associated with uncertainty that are downplayed by cost-benefit analysis and risk assessment methodologies;
3. emphasizes long-term risk reduction over short-term risk management;
4. encourages deeper and broader public engagement in policymaking.

In this report, we agree with the importance of many of these considerations. Indeed, we center our recommendations, discussed in Chapter 7, on arguments that the process of identifying risk is driven by values not captured in conventional risk analysis, and that public deliberation is an essential component of dealing with uncertainty in environmental management. Yet, after closely evaluating the PP and related alternative approaches, we suggest that in complex environmental policy debates, adaptive collaborative management is likely to be more practical and effective than the PP in integrating science and values and in defining, balancing, and achieving desired social, economic, and environmental goals.

1. Safety First

Strong versions of the PP would ban activities that have the potential to harm human health or the environment, even if the scientific case for cause and effect is uncertain. Weaker versions would call at minimum for not rushing ahead with new technologies, products, or processes until risks and options have been carefully considered. No matter the formulation, the PP generally includes the understanding that the burden of proof is shifted from regulators who have to prove that a proposed activity is dangerous to proponents who have to prove that the proposed activity is safe. This shift makes it more difficult to introduce new technologies, products, or processes and automatically results in a slower, more safety-conscious approach to potentially harmful activities.

Sentiments in favor of precaution have been interpreted as allied with "the emotions of misgiving and guilt"(Jordan and O'Riordan 1999, p. 15). In this view, citizens see the destructive effects on human and ecological communities of runaway industrialization and technological development and wish to reign in the excesses of modernization (Beck 1992). The modern culture of "progress" based on domination of nature through scientific and technological prowess is seen as founded on dangerous hubris likely to lead ultimately to the breakdown of ecological and economic systems. This idea has roots in the notion of the Faustian bargain, or a deal with the Devil. Warnings against the potential destructive power of human knowledge are as old as the story of Adam and Eve in Genesis and were raised again in modern form by Goethe in the early nineteenth century (von Goethe 1949 [1832]). In *Faust*, the protagonist oversees massive industrial development in what we would now call a wetland, with dire personal and social consequences. Advocates of the PP tend to distrust economic growth and see technology as a dangerous double-edged sword. Politically, the precautionary approach is often aligned with anti-globalization (Mander and Goldsmith 1996), communitarianism (Daly and Cobb 1989), eco-feminism (Merchant 1980), and environmental stewardship (Brown 1994).

Clearly, technological advances often generate both benefits and unintended adverse consequences. The potential for catastrophic adverse impacts may be increasing as humans gain the ability to manipulate atoms, genes, ecosystems, and even the global climate in ways and on a scale that were not previously possible. PP advocates provide an important service in promoting a concern for safety and a consideration of potential adverse consequences.

2. An Alternative to Conventional Analyses

Advocates for the PP note weaknesses in commonly used analytical techniques for assessing threats to human health and the environment. Cost-benefit analysis, for example, is based on the assumption that all relevant costs and benefits can be monetized, summed, and compared. In principle, this approach can generate comprehensive dynamic assessments that take into account all effects, whether positive or negative, on complex interconnected ecological and economic systems—both in the present and over time. In practice, however, this basic assumption underlying cost-benefit analysis cannot

be met. Many aspects of the world cannot be priced or otherwise compared effectively. Many lines of cause and effect are not clear. The appropriate value to be placed on future impacts remains highly controversial. Moreover, PP advocates argue that by discounting costs and benefits that occur in the future, this type of analysis is biased in favor of technological or commercial undertakings that may generate relatively quick economic or quality-of-life gains but may also threaten long-term environmental damage. Similarly, cost-benefit analysis is biased against actions, such as reducing greenhouse gas emissions, that may produce short-term economic losses but generate large future environmental and social benefits.

According to PP proponents, risk analysis is subject to analogous weaknesses. Risk analysis assumes, for example, that hazards and exposure levels are known or can reasonably be estimated. This is difficult enough in the case of toxic substances or carcinogens, but it may be next to impossible for complex environmental problems in which ecosystem responses and health and economic feedback mechanisms are poorly understood.

Moreover, as we discuss in more detail elsewhere in this report, defining risk can be seen as an expression of values and political influence (Auberson-Huang 2002). Risk assessment includes calculating the likelihood and potential seriousness of particular outcomes, but it also includes implicit valuations of the importance of the social or ecological characteristics that may be affected. In matters of human health, this process may not be controversial: human life and health are generally accepted to be of primary importance. In complex environmental dilemmas, however, there may be competing interests about which there is no general consensus. To give one example: Do ecological risks to spotted owls outweigh economic risks to local human communities that depend on timber harvested from owl habitat? Standard risk analysis and management practices are poorly equipped to address such value-laden controversies.

3. Long-Term Risk Reduction

Advocates of the PP propose a strategy of "backcasting" as opposed to forecasting (Raffensperger and Tickner 1999). Cost-benefit analysis and risk assessment depend on projecting forward from the present, estimating likely outcomes, and presenting judgments about the value and safety of proposed activities or policies.

The PP is based on a fundamentally different perspective. In the precautionary view, instead of making judgments about where particular current innovations may lead, and therefore whether on balance they should be implemented, society should envision a desirable future and then devise strategies for reaching it. In this approach, in lieu of haphazardly introducing new ways of doing business that should be—but typically are not—evaluated to determine whether their inherent risks are tolerable, society would instead direct its energies to developing technologies, products, and processes that help achieve broadly accepted goals.

Although it can be criticized as a utopian approach that ignores political and economic realities, this perspective has the benefit of encouraging holistic, long-term thinking about how to reduce risk proactively, instead of following the commonly applied current strategy of managing risk reactively on a case-by-case basis.

4. Public Participation and Deliberation

Applying the PP promotes deeper and broader public engagement than is currently the norm in environmental policy making. First, as mentioned earlier, proponents of the PP assert that risk characterization is a value-based process and therefore that risk cannot be determined accurately if stakeholders do not have a chance to express their judgments. Second, in questioning cost-benefit analysis, PP proponents reject the primacy and authority of experts. The PP assumes that in highly complex cases with great uncertainty about outcomes, experts alone cannot determine the best course.

There has been considerable movement towards public participation in recent decades. In the environmental arena, formal requirements for public involvement began with the National Environmental Policy Act's mandate that public hearings be held during the development of environmental impact statements. The ongoing SNFPA decision process, as an example, has involved more than a decade of engagement with a wide variety of stakeholder groups. Nevertheless, it is still rare for the public to have real opportunities to be full partners in decision making. Although we agree in this report that enhanced public participation is important, we argue ultimately that some form of adaptive collaborative management would be a preferred mechanism for promoting and utilizing robust public engagement.

Weaknesses

The PP is subject to strong criticism (e.g., Keeney and von Winterfeldt 2001; Starr 2003; Sunstein 2003). Critics argue that it:

1. is not clearly defined and is inconsistently interpreted,
2. does not consider risks that may arise from precautionary actions,
3. does not provide clear guidance to policy makers, and
4. is political and intuitive rather than rational and analytic.

In this report, we conclude that these criticisms are sufficiently telling to undermine the PP's value as a policy-making tool. We argue that the important positive contributions of the precautionary approach discussed in the previous section can be achieved through adaptive collaborative management, and that this approach ultimately provides a more practical and effective response to scientific uncertainty in environmental management.

1. Unclear Definitions

As noted earlier, the precautionary principle has been articulated in various ways, some strong and some weak, and there is no consistent and generally accepted formulation. Moreover, the precautionary principle has become one of the concepts—along with

"sustainable development" or "public participation," to give other examples—that are frequently included in laws, treaties, and declarations to accommodate public concern without providing clear definitions or meaningful mechanisms for implementation.

Moreover, where proponents cite examples in which the PP is clearly defined and effectively implemented, the effects are generally preventive rather than precautionary, as we have distinguished these terms. Preventive measures, in this context, are those that respond with regulation to health and environmental risks in cases where direct scientific evidence of cause and effect may be lacking, but where adverse outcomes are well recognized and likely. These include, for example, constraints on toxic emissions, requirements for workplace safety procedures, and mandates for extensively testing new pharmaceuticals. Although these cases follow the logic of the PP by transferring the burden of proof to the proponent of the potentially risky product or activity, they are less controversial than situations in which evidence for potentially adverse outcomes is more tenuous and costs of regulation are significantly higher.

2. Risks of Precautionary Actions

PP proponents often focus on a single component of an environmental policy problem. By ignoring ripple effects likely to occur across dynamic, complex systems, they may overlook adverse outcomes of the proposed precautionary actions themselves.

The SNFPA decision dilemma provides an important example. Given the goal of maintaining viable populations of old-growth-dependent species, the PP has been used to support severe restrictions on timber harvesting. The precautionary argument is that (1) timber harvesting is intrinsically damaging to natural forest structures and processes; (2) there is no guarantee that even if done in the most environmentally friendly manner possible it would not threaten biological diversity; therefore (3) it should not be permitted. Yet, eliminating timber harvesting may contribute to excessive fuel build-up in the forests. This build-up, in turn, may promote stand-destroying fires, which themselves threaten to destroy species and habitat. Thus, an alternate precautionary argument could be that (1) catastrophic fires are a threat to biological diversity; (2) it is unlikely that natural forest processes can reduce fuel loads without going through an extended period of catastrophic fires; therefore (3) selective timber harvesting carefully managed to minimize ecological harm should be undertaken as a component of a comprehensive fire management strategy.

3. Weak Guidance to Policy Makers

As these criticisms suggest, the PP does not provide useful, practical guidance for natural resource managers who must address complex, real-world dilemmas. When applied to wicked problems—in which all policy alternatives, including the status quo, involve risks—the PP may support no action, or two or more contradictory actions. As noted above, precautionary arguments intended to protect old-growth habitat can be used to support both extensive forest thinning and no forest thinning. I.e., it can be argued both that fuels treatment will directly harm essential old-growth habitat by disturbing

ecological processes, and that fuels treatment will indirectly protect the same habitat by reducing the risk of catastrophic stand-destroying fires. Moreover, depending on specific forest conditions, either or both of these effects may actually occur in the field.

In practical policy making, managers are required to estimate, balance, and aim for compromise among the potential positive and negative effects of all courses of action, including the no-action alternative. Yet general application of the PP restricts flexibility in implementation. According to Forest Service assessments (USDA Forest Service 2003), precautionary thinking inherent in both the SNFPA ROD and the Northwest Forest Plan limited the forest supervisors' ability to adapt to varied conditions in the field or to react when initial strategies failed to produce desired results. Consequently, efforts intended to protect forest habitat and other social and environmental values may in practice do more harm than good.

4. Intuitive Rather Than Rational

The PP incorporates important common-sense, safety-first ideas. As we argue above, these ideas need to be taken into account as policy strategies are developed. Yet precautionary thinking also often includes logical inconsistencies that weaken its usefulness as a practical policymaking tool (Sunstein 2003). Examples of these problems include:

- We want to keep what we have even if what we may gain by giving it up may be more valuable.
- We tend to focus on immediate concerns while ignoring important issues that are temporarily out of sight.
- In cases involving extremely unlikely adverse events, we focus on potential dramatic negative outcomes rather than on the very low probabilities of these outcomes actually occurring.
- We tend to ignore trade-offs—i.e., we tend to focus on a single factor and overlook significant effects on other system components.

Moreover, in its strongest versions, the PP may be anti-scientific. Strong formulations of the PP may dismiss scientific findings that acknowledge any level of uncertainty and may settle on a default position biased against all new technologies or environmental management strategies. As we acknowledge, uncertainty can also be abused as an excuse to go forward with risky activities. While scientific uncertainty can be used to support or oppose precautionary measures, neither response is appropriate in all circumstances (Keeney and von Winterfeldt 2001). Precautionary thinking can play an important role as wicked environmental problems are framed and assessed, but policies implemented in the field need to be flexible to allow rapid application of new knowledge and quick responses to unexpected outcomes.

Proposed Modified Versions of the Precautionary Principle

While risk assessment and cost-benefit analysis may underestimate important questions of values and may downplay possible long-term adverse effects, the PP may ignore

economic or environmental trade-offs and may limit management flexibility in the field. Several alternative, middle-ground approaches have been proposed for responding to criticisms of the PP (listed above) and for strengthening its effectiveness as policy tool. These include:

1. Apply the "maximin" principle (Comba 2002): That is, choose the policy alternative with the least bad worst-case scenario.
2. Apply "risk–risk" analysis (Goklany 2001): That is, assess all risks throughout the system, including those resulting from trade-offs and ripple effects, and choose the policy alternative that minimizes net risk.
3. Avoid the "dichotomy trap" (Stirling and Calenbuhr 2000; Peterson 2002): That is, incorporate the strengths of both scientific and precautionary approaches.

The first, based on the principle of catastrophe aversion, suffers many of the same limitations as the PP. For example, it ignores the probabilities that the worst-case scenario will occur. In other words, it may lead to eliminating policies that are likely to lead to desired outcomes because they have some possibility—no matter how remote or unproven—of leading to a catastrophe. Also, this alternative assumes no scientific ignorance. That is, it does not avoid the possibility that a policy chosen based on the catastrophe-avoidance criterion may lead to an entirely unforeseen catastrophe.

The second is closer to conventional risk assessment and cost-benefit analysis and incorporates several of the weaknesses of these approaches identified above. For example, it assumes that all risk can be identified, agreed upon, quantified, and compared. Significantly, this information burden is likely to increase, rather than decrease, as risk analysis is scaled up to the system level in the context of wicked environmental problems.

The third proposes to defuse the struggle over the PP by integrating precaution and science. As the SNFPA ROD process demonstrates, however, such a compromise will be difficult to achieve given the present tendency toward political stalemate in complex environmental dilemmas.

PRECAUTIONARY PRINCIPLE: A SUMMARY

We acknowledge that precautionary thinking can make important, positive contributions to debates over complex environmental dilemmas. Benefits include focusing heightened attention on:

- the potential for long-term, multigenerational effects of policy decisions,
- the potential for severe, adverse, unintended consequences,
- the limitations of cost-benefit and risk assessment methodologies, and
- the importance of public participation and recognition of diverse values.

Nevertheless, after analyzing strengths and weaknesses, we find that the PP as currently understood is not an effective, practical guide for policymaking when confronting wicked problems. In particular, the PP:

- is not clearly defined;
- does not account for the potential adverse effects of precautionary actions themselves;
- does not provide clear guidance to policymakers; and
- has become highly politicized.

As we argue elsewhere in this report, we believe a form of adaptive collaborative management has promise as a practical and an effective compromise approach, incorporating public values and protecting against catastrophe while promoting experimental learning and management flexibility.

OTHER RESPONSES TO UNCERTAINTY

Thus far we have focused on the precautionary principle because precautionary thinking has had a particularly strong influence on public attitudes and management choices. In the second half of this chapter, we briefly review three additional responses to risk and uncertainty in environmental management that are discussed in the literature and have been applied in the field: establishing safe minimum standards (SMS), protecting critical natural capital (CNC), and implementing best management practices (BMP).

Safe Minimum Standards

Types of Uncertainty Addressed

The safe minimum standards (SMS) approach addresses uncertainty in future trends in knowledge, technological capabilities, and social values (Ciriacy-Wantrup 1961; Bishop 1978; Crowards 1998). The concern is that natural resources threatened with irreversible loss today may turn out to be significantly more valuable in the future (if they indeed survive) than estimated at present as options to exploit or conserve the resources are considered. Such revisions in valuations may occur as people in the future come to discover economic benefits inherent in the resource that are currently unknown, develop technological abilities to extract economic values that are not currently recoverable, or evolve social norms that find non-use, existence, aesthetic, or other non-market values that are not now recognized.

Working Definitions

Hanley (2000, p. 23) offers the following explanation of the SMS decision rule: "The SMS rule is: prevent reductions in the natural capital stock below the Safe Minimum Standard identified for each component of this stock unless the social opportunity costs of doing so are 'unacceptably' large."

Crowards (1998, pp. 312-313) describes the SMS decision criterion this way:

> An SMS decision-rule places a bound upon what might otherwise be economically rational actions, whenever such actions threaten irreversible damage to the environment. It recommends that in such instances the environment should be protected unless the social costs—estimated on the basis of a full economic

evaluation—are regarded as "unacceptable." It does not therefore obviate the need for careful economic assessment of both development and preservation costs and benefits, but recognizes instead some of the shortcomings of a purely economic approach and provides a framework within which to deal with these.

History

Ciriacy-Wantrup (1952; 1961) first proposed the idea of using safe minimum standards as a tool for addressing risk and uncertainty in environmental decision-making. He suggested that when a proposed action entails some risk of irreversible environmental loss, indicated by the possibility that the action would reduce a threatened resource to a level from which it could not recover (i.e., below an established SMS), the activity should be halted or banned. He argued that establishing SMSs for important natural resources or conditions would minimize the likelihood of catastrophic and irremediable environmental losses from human activities—a so-called minimax decision-making criterion (Tisdell 1990; Hanley 2000).

Bishop (1978; 1979; 1980; 1993), focusing specifically on risks to endangered species, worked to operationalize the concept of SMS by incorporating it within the framework of cost-benefit analysis. He argued that SMSs, typically stated as minimum viable populations that would provide adequate margins of safety to ensure long-term survival of threatened species, should be maintained unless the total social costs of foregoing development to protect the species were deemed unacceptable. By adding this final clause, Bishop stepped back from Ciriacy-Wantrup's more absolutist proposal that required adherence to an established SMS regardless of the circumstances (Crowards 1998).

Conventional economic cost-benefit analysis, Bishop argued, could be used to approximate the net total social benefits or costs of conservation—i.e., of maintaining the established SMS in any particular case—by subtracting the estimated benefits of preserving an endangered species (and its habitat) from the opportunity costs associated with not going forward with the economic development activity that threatens it. However, this approach assumes, as later made explicit by Crowards (1998), that conservation benefits include two components: benefits that can be known or estimated based on current knowledge, technology, and social values (and thus incorporated into cost-benefit analyses), and unknown potential future benefits that may arise as knowledge, technology, and social values evolve over time (benefits that cannot presently be quantified or monetized).

If a proposed project fails to pass a cost-benefit test given analysis of currently estimable costs and benefits, then the project should not be undertaken. The SMS approach, however, adds a further level of environmental protection by establishing the idea that the bar for approving proposed actions that threaten irreversible environmental harm, such as the loss of a species, should be raised by (1) assuming the existence of unknown future potential benefits that would accrue to society if the species were protected, and (2) requiring that the opportunity for future generations to extract these potential benefits be

preserved unless it is otherwise judged unreasonable to do so. These goals would be achieved by setting safe minimum population standards for the threatened species that would trump cost-benefit analyses based on currently knowable costs and benefits unless the estimated total social costs were judged unacceptable. In this formulation, determination as to whether the SMS should stand or be overridden—i.e., whether the activity under consideration should in fact be banned to protect the resource and the potential, but unknowable, future benefits it might provide—would be removed from the hands of expert analysts and decided in the political realm (Ciriacy-Wantrup 1961; Toman 1994; Crowards 1998; Hanley 2000). Woodward and Bishop (1997) have argued that applying the SMS approach is the rational response to decision making under conditions of uncertainty in environmental management (Hanley 2000).

There have been detours from the line of argument regarding SMS developed by Ciriacy-Wantrup and Bishop. While Bishop specifically attempted to ground the concept in the language of cost-benefit analysis, some scholars have interpreted SMS as an alternative analytic tool in direct conflict with conventional neoclassical economic approaches (e.g., Vatn and Bromley 1994; Barbier, Burgess et al. 1995). Others have suggested that SMS provides those who favor environmental protection over economic development both a justification for avoiding the arduous task of estimating conservation benefits (particularly non-market or presently unknown benefits) and a mechanism for overcoming the commonly noted problem that discounting known conservation benefits over time to conform to cost-benefit calculations frequently makes it difficult for long-term environmental benefits to outweigh more immediate economic benefits linked to exploiting resources (e.g., Norton 1986; Brown 1994; Rogers and Sinden 1994). In other words, in this perspective, SMS would automatically override the outcomes of any cost-benefit analysis.

In contrast, the SMS approach as described by Ciriacy-Wantrup and Bishop, and summarized by Crowards (1998), requires and depends upon assessments of costs and benefits that are as complete as possible. In this view, the remaining uncertainty associated with unknown future conservation benefits would be addressed by requiring that non-economic criteria be used in the political arena to determine whether the estimated opportunity costs of adhering to SMS are "acceptable"—i.e., whether society is willing to forego the benefits of economic development in a particular case to avoid the risk of an irrevocable loss of unknown future environmental benefits.

Strengths and Weaknesses

The primary strength of the SMS approach is that it encourages acknowledging potential benefits of conservation that may be overlooked in conventional economic analysis. Adhering to established safe minimum standards may thus help society avoid inefficient allocation or distribution of resources over time, either within or across generations.

The SMS approach is subject to at least three significant practical problems, however (Hanley 2000):

1. How are SMSs to be established?
2. How broadly can the SMS approach be applied?
3. How can society reasonably judge whether estimated social costs of adhering to a given SMS are "unacceptable"?

The first question highlights the difficulty of determining safe minimum standards for species viability when there are significant gaps in the knowledge base and when ecological conditions are dynamic. For species with known reproductive parameters and habitat requirements, computer models can be used to estimate responses to threats and disturbances and thus predict safe minimum populations over a range of ecological conditions. The largest of the SMS estimates generated by computer models could be set as the minimum standard. For many species, however, reproductive and habitat data are not readily available or are uncertain. Moreover, probabilities of catastrophic ecological disturbances occurring may also be poorly characterized. In such cases, the SMS may have to be set unrealistically high or altered frequently. Moreover, requiring judgments for appropriate levels of SMSs to be made for multiple interacting species at the community and/or ecosystem level is likely to create an unmanageable information and analytic burden.

The second question concerns the range of natural resources for which SMSs can realistically be set. To date, the SMS approach has primarily been applied in cases involving endangered species (e.g., Hyde 1989; Montgomery, Brown et al. 1994). In principle, however, SMSs could be established for the full range of natural resources and conditions—everything from local wetlands to the global atmosphere and climate—that are both threatened by human activity and potentially undervalued in cost-benefit analyses. However, problems scientists face in attempting to set appropriate standards for individual species will apply equally to every other facet of the natural world, raising doubts that SMSs can be practically and usefully established.

The third question points to the problem that an essential component of the SMS approach is undefined. In order to determine whether estimated social costs of conservation are "unacceptable" in any particular case requires society to trade off the estimated value of economic development against intrinsically unquantifiable potential future benefits of conserving the resource that the development activities threaten. The SMS approach provides no guidance for how the political process should make such judgments—i.e., how the present generation should take into account the unknown preferences of future generations.

Links to Other Responses to Uncertainty, and Relevance for the SNFPA Decision Process

The SMS approach to decision making under conditions of uncertainty is closely related to the precautionary principle. Like the PP, SMS shifts the burden of proof from conservationists to developers (Hanley 2000), thus creating a decision rule that favors environmental protection over economic development. The main differences between SMS and the precautionary principle are that the SMS approach (1) accepts the

importance of assessing the costs and benefits of both conservation and development, (2) allows the resource in question to be exploited as long as the SMS is maintained, and (3) allows the resource to be exploited beyond the safe standard under exceptional circumstances when the known social costs of foregoing the environmentally damaging economic development are judged unacceptably high.

Safe minimum standards were not explicitly established for threatened species and habitat in the SNFPA case. Instead, the SNFPA FEIS and ROD established standards and guidelines designed to ensure that old-growth forests and associated species would not be significantly harmed by agency actions (USDA Forest Service 2001a). However, subsequent analyses presented in the SNFPA Review Team report suggested that this precautionary approach, by limiting management options, may actually have had the unintended effect of making it more difficult to protect threatened species and habitat in the Sierra Nevada National Forests (USDA Forest Service 2003). Reviewing outcomes for the Northwest Forest Plan in northern California generated similar findings (Thomas 2003b).

Critical Natural Capital

Types of Uncertainty Addressed

The critical natural capital (CNC) approach (also referred to in the literature as "constant natural capital" or "strong sustainability") addresses uncertainty in technological and economic changes over time. Through applying improved technology (Thomas 2003b), society may reduce dependence on many scarce natural resources by increasing efficiency in their use or by developing new products and processes that perform the same functions. At any given time, however, some natural resources and systems provide materials or services to the human economy that are vital and non-substitutable. Although the core set of natural products and processes that make the planet habitable remain permanently essential, the broader pool of natural capital deemed critical and non-substitutable at any given time changes as technology advances and the economy undergoes structural changes. Some resources that presently appear non-substitutable may drop from the list as alternatives are developed or as the economy switches to new activities. Conversely, other resources that are not currently judged vital for maintaining and improving human well-being may become so in the future. Yet these technological and economic changes are unpredictable, leading to uncertainty in determining which resources need to be permanently protected from unsustainable use. The CNC approach attempts to address this uncertainty by identifying and holding constant the critical natural capital for which there can be no manmade substitutes: it is closely linked to the idea of sustainable development (Pearce, Barbier et al. 1989; Ledoux and Turner 2002).

Working Definitions

Daly (1996, p. 80) defines natural capital as follows:

> *Natural capital* is the stock that yields the flow of natural resources—the population of fish in the ocean that regenerates the flow of caught fish that go to

> market; the standing forest that regenerates the flow of cut timber; the petroleum deposits in the ground whose liquidation yields the flow of pumped crude oil…. Natural capital is divided into two kinds, as represented by the examples given: renewable (fish, trees), and non-renewable (petroleum). (emphasis in original.)

Hanley, referring to the substitutability of manmade capital (*Km*) for natural capital (*Kn*), defines *critical* natural capital (see also Pearce, Barbier et al. 1989) as follows:

> [W]hilst some substitution is possible between certain elements of *Kn* and *Km* (for example, better machinery meaning less raw materials are used to produce certain products), many elements of *Kn* provide non-substitutable services ("keystone processes") to the economy. Examples of such "critical" natural capital are the processes responsible for regulation of atmospheric composition, the spiritual values provided by wildlife, and nutrient cycles…. Preventing declines in *Kn* is often referred to as "strong sustainability."

Costanza and Daly (1992, p. 37) describe the constant natural capital rule as follows:

> A minimum necessary condition for sustainability is the maintenance of total natural capital stock at or above the current level. While a lower stock of natural capital may be sustainable, society can allow no further decline in natural capital given the large uncertainty and the dire consequences of guessing wrong. This "constancy of total natural capital" rule can thus be seen as a prudent minimum condition for assuring sustainability, to be relaxed only when solid evidence can be offered that it is safe to do so.

History

The concept of natural capital, and arguments in favor of preserving the aggregate stock of natural capital intact, arose during the development of the discipline of ecological economics in the 1980s. Economists had tended to view the natural environment as a free and unlimited storehouse, both as a source of economically valuable inputs and as a sink for absorbing unwanted byproducts of economic activity. Conversely, ecologists, while understanding that the natural environment is a complex, interconnected system comprising both living and non-living components, had tended to overlook the impacts of humans and the human economy. Ecological economics was developed to integrate these divergent disciplines and explore and address emerging concerns about the sustainability of economic growth given ecological constraints (Costanza, Cumberland et al. 1997).

The idea of sustainable development as an international goal gained currency during the run-up to the Earth Summit (the United Nations Conference on Environment and Development) held in Rio de Janeiro in 1992. A 1987 report by a commission convened under the sponsorship of the United Nations, commonly known as the Brundtland Commission Report, defined sustainable development as economic development that allows the present generation to meet its needs without limiting the ability of future generations to meet their needs (World Commission on Environment and Development 1987). This definition clearly implies that critical natural capital must be preserved for future generations. However, it did not settle the question, which continues to be the

subject of heated debate (e.g., Daly 1997; Pearce 1997; Solow 1997; Stiglitz 1997), about what natural capital, if any, is non-substitutable and thus should be held constant to ensure that economic development is sustainable over the long term.

To simplify a complex controversy, many neoclassical economists argue that in most cases manmade and natural capital are substitutes (e.g., Solow 1997; Stiglitz 1997) and that correct pricing in competitive markets will promote efficient use of these resources. This view is commonly referred to as "weak sustainability." Many ecological economists, on the other hand, generally view manmade and natural capital as complements, and only marginally as substitutes (e. g. Georgescu-Roegen 1979; Daly 1996) and argue that markets generally under-price natural resources and thus contribute to unsustainable overexploitation. This view is commonly referred to as "strong sustainability" (Ledoux and Turner 2002).

Strengths and Weaknesses

The CNC approach to uncertainty in environmental management has many of the same strengths and weaknesses as applications of SMS and the precautionary principle (Ledoux and Turner 2002). The approach's key strength is that it focuses attention on sustainability—that is, on the risk that economic development may permanently deplete vital components of the natural environment and thereby impoverish those in the future who will have to live in a degraded world (Destler and Balint 2000). An important weakness of the approach is that it raises but does not resolve questions concerning (1) what resources are critical and non-substitutable and (2) what are the relevant threshold levels below which these resources must not be reduced. Pearce (1997, p. 297) summarizes the problem as follows:

> And if there are thresholds, then criticality may be something that emerges only after a point of no return, an irreversibility. The problem lies in not knowing where the thresholds are for many natural resources, or even if there are such thresholds. We may well be able to do without some of the Amazon forest, but one hazards a guess that we are extremely unlikely to do without any of it. Who among us can say what the switchover point is? And if we do not know the answers to these questions then the appropriate responses surely are: (a) to invest in more and better information; and (b) to behave cautiously in the meantime.

Links to Other Responses to Uncertainty, and Relevance for the SNFPA Decision Process

The CNC approach is similar to the original idea of safe minimum standards as proposed by Ciriacy-Wantrup (1952). That is, CNC includes the idea of a critical threshold below which a resource should not be depleted, but it does not include the escape clause added by Bishop (1978) that would allow exploitation of the resource beyond the threshold if the social costs of foregoing the economic activities in question were deemed unacceptable. One notable difference, however, is that the CNC approach is often applied to global or broad-based resource issues, whereas SMSs are more frequently applied to specific, local concerns, particularly populations of endangered species.

In the quotation cited in the preceding section, Pearce suggests that when it is not clear which natural capital is critical and whether and where threshold levels exist, the precautionary principle can serve as an appropriate fallback position. This, however, does not resolve the problems that arise when the precautionary approach is applied to "wicked" environmental problems in which there are multiple and compounding political, economic, and scientific uncertainties and the time frame is multigenerational. First, it is generally not possible in such circumstances to collect sufficient information to determine which resources are critical or to solve the threshold puzzle, and, second, caution does not guarantee beneficial outcomes when, as in the SNFPA case, maintaining the status quo itself carries significant environmental and economic risks.

Best Management Practices

Types of Uncertainty Addressed

The best management practice (BMP) approach addresses uncertainty in ecological outcomes of economic and resource management activities. While the SMS and CNC approaches discussed above call into question the wisdom of further economic growth given ecological constraints, the BMP approach assumes that human activities affecting the environment are going to go forward, and works to minimize the harm that may occur as a result of those activities. Adherence to BMPs may also help agencies and firms avoid shorter-term legal or regulatory uncertainty. That is, agencies or firms that abide by mandated BMPs are likely to have some protection from lawsuits or statutory sanctions.

Working Definitions

The United States Environmental Protection Agency (U.S. Environmental Protection Agency 2004) defines the BMP approach as follows:

> Best management practices are methods that have been determined to be the most effective and practical means of preventing or reducing pollution. These practices are often employed in agriculture, forestry, mining and construction…. The ultimate goal of these practices is to increase efficiency while reducing pollution.

Looking particularly at forest resource issues, Ellefson and Hibbard (2003, p. 4) offer the following definition of BMPs:

> Best practice codes are typically summations of various forest practices that are considered to be technically, economically and politically acceptable for achieving certain desired conditions of forest sustainability. Their development by public and private agencies usually involves collaborative processes wherein the final sets of best practices are those that meet sustainable forest conditions as well as the biological, economic and social interests of those that are engaged in their development.

History

The concept of best management practices was first developed by foresters during the late nineteenth and early twentieth centuries. Gifford Pinchot and other Progressive Movement pioneers of scientific forestry designed and promoted practices intended to minimize soil erosion and water pollution and to sustain timber yields (Forest History Society 2000). In forestry, BMPs are also known variously as best practice codes, forest practice guidelines, forest practice rules, acceptable practices, and management ordinances (Ellefson and Hibbard 2003).

Although derived from forestry, these standards and the underlying concepts later served as a foundation for legal mandates requiring protecting water resources incorporated in statutes such as the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act) and the Coastal Zone Management Act of 1972. These laws require federal and state agencies to establish and enforce BMPs for agriculture, aquaculture, silviculture, mining, construction, and other activities as part of their efforts to protect streams, rivers, lakes, and estuaries from runoff and other pollutants (Ellefson, Kilgore et al. 2001). BMP requirements may include, for example, adhering to effluent standards, protecting wetlands, and maintaining buffer zones in riparian areas (Twery and Hornbeck 2001). Various other federal laws also now incorporate BMPs to promote desired outcomes. Those particularly relevant for the national forests include the National Forest Management Act of 1976 and the Endangered Species Act of 1973 (Ellefson and Hibbard 2003).

At the federal level, the EPA, the Forest Service, and the Fish and Wildlife Service have taken the lead in promulgating BMPs to protect watersheds, coastal regions, and endangered species, and to promote sustainable resource management. State agencies also play an essential role, particularly in monitoring and enforcing on state and private lands.

The effectiveness of BMPs has been shown to depend on various factors, including the availability of extension and education services, the extent of landowners' or resource managers' skills and experience, the presence of credible monitoring and enforcement, and the centralization of authority in a single responsible agency (Izuno and Capone 1995; Ellefson, Kilgore et al. 2001).

Over the past decade or so, voluntary programs encouraging private firms and other landowners to institute BMPs where not required by law or to exceed existing legal standards have arisen to supplement statutory or regulatory mandates (Ellefson, Kilgore et al. 2001; Ellefson and Hibbard 2003). Firms may participate to enhance their public image or to reduce costs as they manage the natural resources under their control more efficiently and sustainably (Rivera 2002). Government agencies, nongovernmental organizations, and trade associations provide various incentives for participation. A common approach involves certification programs that may allow firms to attach a "green" label to their products or to qualify for price premiums in the marketplace. Such

programs now exist both domestically and internationally for timber, coffee, tourism, and other products and services (Rivera 2002; Ellefson and Hibbard 2003).

Strengths and Weaknesses

The key strength of the BMP approach to environmental management is that it sets standards or benchmarks for performance against which activities that impact the environment can be measured. When implemented effectively, BMPs can reduce ecological degradation and promote sustainable use of natural resources (Nisbet 2001).

In practice, however, several weaknesses have been noted (Izuno and Capone 1995; Schuler and Briggs 2000; Ellefson, Kilgore et al. 2001; Twery and Hornbeck 2001). These include the following, among others:

1. BMPs are often general rather than specific or targeted. That is, they typically prescribe activities without formalizing numerical targets, and they rarely incorporate the flexibility necessary to adjust to varying local conditions.
2. BMP programs and guidelines, whether statutory or voluntary, may be slow to adapt to changing technologies and ecological conditions.
3. The term "best management practices" may be a misnomer. Instead of being literally the best that can be accomplished, BMPs may rather represent minimum performance standards required to comply with regulations or satisfy certification criteria.
4. Private firms and industry associations may find that BMP guidelines are impractical or overly complex and add to what they perceive to be an already onerous regulatory burden.
5. BMPs depend for success on effective monitoring and enforcement. Yet, responsible agencies at the federal, state, and local level often lack the necessary expertise and financial wherewithal to carry out these tasks.

Links to Other Responses to Uncertainty, and Relevance for the SNFPA Decision Process

The BMP approach is a tool for addressing both ecological and regulatory uncertainty. In terms of ecological uncertainty, BMPs—if appropriately designed and effectively enforced—can reduce adverse environmental outcomes while assuring that other social goals are achieved. To maximize such benefits, however, BMPs should be flexible and able to respond to changing circumstances, both across geographical locations and over time. If designed in this way, effective BMPs would be consistent with the principles of adaptive management. Following the logic of adaptive management, BMPs should be developed and implemented—and then modified and improved—in an iterative process based on experience in the field.

While achieving desired social and ecological conditions remains the primary long-term goal of environmental policy making, agencies and firms also have incentives to reduce the administrative and regulatory uncertainties that can constrain their actions in the short term. As we note in elsewhere in this report, we believe that the key immediate risks

facing the Forest Service in the SNFPA case, for example, are related to decision processes rather than ecological outcomes. In such cases, adherence to BMPs can help agencies and firms reduce the risk of regulatory or legal sanctions and, consequently, may permit greater flexibility in responding to calls for broader public engagement and more comprehensive adaptive management.

CONCLUSION

The Pacific Southwest Region manages the Sierra Nevada National Forests in a policy-making environment characterized by multiple and compounding uncertainties. These uncertainties relate to ecological states and processes, social and political preferences and values, and administrative, legal, regulatory, and budgetary conditions and trends. Although in the context of wicked problems these uncertainties cannot be eliminated, various approaches are available for incorporating them into the decision-making process. In this report, we focus primarily on adaptive management and on public deliberation and participation because these alternatives seem to be essential components of any future efforts to address uncertainty in the national forests—and in environmental management more generally.

In this chapter, however, we review several alternative responses to environmental risk and uncertainty that are addressed in the literature and applied in the field. This chapter emphasizes the precautionary principle, as we believe the PP has significantly influenced public attitudes and management choices in the SNFPA process and elsewhere. We also briefly consider three other approaches to environmental uncertainty: safe minimum standards, critical natural capital, and best management practices.

To summarize our findings, we argue that the precautionary principle, despite positive contributions related to safety-first considerations, does not provide useful, practical guidance to environmental managers. We also conclude that the concepts of safe minimum standards and critical natural capital can be seen as variations of the precautionary principle that suffer from the same limitations as the PP when used in response to large-scale, complex environmental dilemmas. In addition, while the idea of best management practices fits within the logic of adaptive management, which we endorse, we find that BMPs are not robust enough or flexible enough to serve as a primary tool for addressing wicked problems. As discussed in Chapter 7, we propose instead an iterative, deliberative, analytic process for managing wicked environmental problems that more completely integrates adaptive management and public engagement.

CHAPTER 6. ADAPTIVE MANAGEMENT AND THE CALL FOR LEARNING BY DOING

INTRODUCTION

The intricate process of effective ecosystem management is multifaceted, requiring both constant innovation and constant recursiveness in the face of risk and uncertainty. Shelhas, Buck et al. (2001) believe that "a complex and changing world of diverse interests and stakeholders leaves little room for simple answers and prescriptions when dealing with resource issues." Holling (1995) suggests that when faced with a fundamental loss of certitude, and when an action seems more prone to costs than benefits, it is tempting to retreat to unsupported ideology, rigid beliefs, or to tightly circumscribed action. The alternative, he suggests, is to "seek new understanding, often through reflective action."

Ecosystem managers may attempt to use conventional economic decision theories and seek optimal solutions to such complex problems, but when conventionally measured economic value conflicts with environmental values, not only are the stakeholders in conflict, but the fundamental premise that a noncontroversial optimal decision can be found is not plausible (Lee 2001).

The strategy of adaptive management in its various iterations—adaptive environmental assessment and management (AEAM), adaptive management, adaptive collaborative management—are commonly accepted approaches to dealing with such problems. Before discussing how adaptive management handles risk and uncertainty, we will define the term. Twenty-five years of real-world examples provide a spectrum of legacy case studies with varying degrees of success, each of which teaches crucial lessons for applying this strategy.

This chapter will show that adaptive collaborative management that includes identifying and developing facilitated stakeholder networks invests all parties in understanding ecosystem management impacts. It also necessitates recurring evaluation, experimentation, and policy and procedure adjustment. Adaptive collaborative management, in other words, is a demonstrably acceptable, but not completely sufficient, approach to solving large-scale wicked problems.

DEFINITION

The term "adaptive management" has many interpretations, which is not surprising given the different perspectives and backgrounds of the numerous stakeholders involved in natural resource issues. Some managers see good management as "adaptive," simply meaning a willingness to change (Wilhere 2002). Others see adaptive management as "flexible management," an opportunity to contest policies with which they disagree.

The most common alternatives to adaptive management are *deferred action* and *trial and error* (Wilhere 2002). Under *deferred action*, an ecosystem is not managed until after it is understood. Only minimal disturbance is allowed while research is conducted to determine important processes and relationships. This approach is cautious but has an economic cost due discounting future revenues. Further, behavior of an undisturbed ecosystem can be very different from that of a managed ecosystem, so the knowledge acquired while deferring action may not be applicable to the managed system (Wilhere 2002).

Trial and error continues to be the dominant approach in natural resource management (Wilhere 2002). The emphasis is generally on the "trial," entailing resource utilization and revenue production, while largely neglecting error detection, done mostly through costly monitoring. Walters and Holling (1990) refer to this as "learning by doing" or "evolutionary." Unfortunately, casual observations, anecdotal reports, and unreplicated case studies are unlikely to develop reliable information: managers using these types of learning may fail to detect errors and perpetuate bad policy. With trial and error, managers usually implement a single policy and assume it is satisfactory until proved otherwise (Wilhere 2002).

> "The strategy I discuss in this book is adaptive management—treating economic uses of nature as experiments, so that we may learn efficiently from experience. Second, we need to grasp far more wisely the relationships among people. One name for such a learning process is politics; another is conflict. We need institutions that can sustain civilization now and in the future. Building them requires conflict, because the fundamental interests of industrial society are under challenge. But conflict must be limited because unbounded strife will destroy the material foundations of those interests, leaving all in poverty. Bounded conflict is politics" (Lee 1993, p. 8)

According to Lee (1993), natural resource management is a process of using biological information to predict consequences (causation) and sociological information to value those consequences (goals). If managers agree on both consequences and values, decisions can be based on established routine information gathering and evaluating. If there is agreement about effects of management actions, but disagreement about goals, a process of negotiation among the stakeholders is needed to develop acceptable policy. If management goals are broadly accepted, but there is disagreement or uncertainty about the impacts, adaptive management can be a useful tool for addressing and resolving these disagreements. **Adaptive management allows managers to agree on policy when they cannot agree on predicted outcomes; in this context, adaptive management is not a process for coping with disagreement over management goals and objectives** (Johnson and Williams 1999). Obviously, any decision-making process will be limited in its effectiveness if there is ambiguity about the process's goals or objectives.

The term "adaptive management" first appeared in the natural resources management literature in the mid-1970s. The approach borrows heavily from adaptive control process theory, which addresses how to construct decision-making devices, or control devices, capable of learning from experience (Bellman 1961). Adaptive control devices have

feedback mechanisms that either allow information to accumulate automatically, or deliberately probe the environment to gather new information. Because these devices can modify their behavior in response to new information, they are better suited to conditions of uncertainty than nonadaptive control devices. Adaptive management in natural resources, then, also incorporates informational feedback into the management process to accelerate the rate at which environmental decision makers learn from their experience (McLain and Lee 1996). Walters (1986) argues that **scientific understanding of complex natural resource systems with high uncertainty will come from the experience of management as an ongoing, adaptive, and experimental process, rather than through basic research or developing ecological theory.**

Adaptive management borrows from both operations research and management science by relying on systematically using the scientific method and mathematical models to help decision makers make decisions in the face of complexity, changing conditions, and uncertainty about key relationships among system components (McLain and Lee 1996). It is premised on the idea that managers should structure interventions in ways that permit them to anticipate or take advantage of surprise as a tool for learning, rather than attempting to avoid or react to the inevitable surprises that arise (Timmerman 1986). Adaptive management acknowledges that policies must satisfy social objectives, but must be continually modified and remain flexible for adapting to these surprises (Gunderson 1999). Therefore, it views policies as hypotheses and management actions as experiments, in an experimental sense.

In a nutshell, adaptive management is a structured process of "learning by doing," but it involves much more than simply better ecological monitoring and response to expected management impacts (Walters 1997a). A common form of adaptive management used by the USDA Forest Service involves implementing a plan or project direction with monitoring to determine if the results were as expected. More broadly, though, adaptive management includes a variety of actions, ranging from experimentation in which hypotheses are developed and tested to determine how the system responds and to examine alternative approaches, to traditional scientific inquiry, to less formal, trial-and-error approaches (Stankey, Bormann et al. 2003).

According to Walters (1997a), adaptive management's key concept is that management policies must be recognized explicitly as experimental treatments. This means that monitoring and planning management actions must be developed concurrently to form a single adaptive management plan.

There are two forms of adaptive management: *passive* and *active* (Wilhere 2002). *Passive adaptive management* is a scientifically rigorous process of formulating predictive models, making policy decisions based on the models, and revising the models as monitoring data becomes available. The model is used to predict ecosystem responses and, in theory, activities can be designed to disturb the ecosystem in a way that enhances estimating model parameters. Monitoring and evaluation systems are in place before management begins, but monitoring is conducted without controls, replication, or randomization. Therefore, passive adaptive management cannot establish cause-and-

effect relationships between management actions and changes in ecosystem conditions. However, it is relatively simple and inexpensive (Wilhere 2002).

Active adaptive management conducts management actions as deliberate experiments (Wilhere 2002). Alternative policies are viewed as treatments and are implemented through statistically valid experimental design. Monitoring is the experiment's data collection phase. Active adaptive management results in better understanding how and why natural systems respond to management, and responses to a range of treatments can help develop better policy. However, it is more complex and expensive.

The most recent forms of adaptive management begin with synthesizing existing experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies (Walters 1997b). According to Walters (1997b), the modeling step serves three functions:

1. problem clarification and enhanced communication among scientists, managers, and other stakeholders;
2. policy screening to eliminate options that are most likely incapable of doing much good because of inadequate scale or type of impact, especially those that might lead to irreversibility [irreversibility occurs when the ecosystem cannot escape from particular states no matter what action is taken, such as extinction of a species] and
3. identification of key knowledge gaps that make the model predictions suspect.

By leading to designing critical management experiments, modeling, in principle, permits replacing learning by trial and error (an evolutionary process) with learning by careful tests (a process of directed selection).

Thus far the focus has been on integrating science into the decision making. However, most conflicts and difficulties in reaching satisfactory decisions not only involve scientific uncertainty, but stakeholders' conflicts in values and acceptance of risk and uncertainty. Therefore, more emphasis is being placed on the process's social side. For example (McLain and Lee 1996, p. 437),

> Scientific adaptive management relies excessively on the use of linear systems models, discounts non-scientific forms of knowledge, and pays inadequate attention to policy processes that promote the development of shared understanding between diverse stakeholders. To be effective, new adaptive management efforts will need to incorporate knowledge from multiple sources, make use of multiple systems models, and support new forms of cooperation among stakeholders.

Habron (2003) summarizes adaptive management as a series of linked, iterative steps involving problem identification, collaborative brainstorming, model development, hypothesis testing, planning, experimentation, monitoring, evaluation, and behavioral change (Figure 13). While an acceptable and common model of adaptive management, it does not explicitly recognize or consider the role of stakeholders in identifying issues or problems to be addressed by experimentation.

Lee (1993) identifies ten institutional conditions that favor adaptive management:

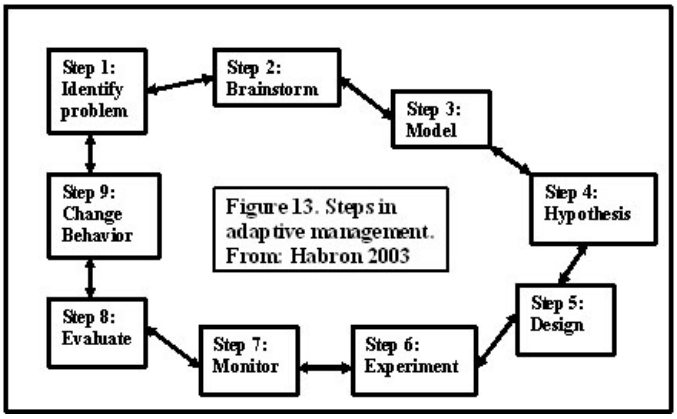


Figure 13. Steps in adaptive management. From: Habron 2003

1. There must be a mandate to take action in the face of uncertainty.
2. Preserving pristine environments must no longer be an option.
3. Human intervention must not be able to produce desired outcomes predictably.
4. There must be sufficient institutional stability to measure long-term outcomes.
5. It must be possible to formulate hypotheses.
6. Theory, models, and field methods must be available to estimate and infer ecosystem-scale behavior.
7. Decision makers must be aware that they are experimenting.
8. Organizational culture must encourage learning from experience.
9. Resources must be sufficient to measure ecosystem-scale behavior.
10. Decision makers must care about improving outcomes over biological time scales.

Local experimentation and landscape level experimentation are not mutually exclusive. Adaptive management has two feedback components:

1. Carefully planned monitoring of policy implementation: were the planned objectives achieved?
2. Carefully designed experimentation to test the policy's (and associated planning models') explicit and implicit assumptions or to test alternative policies.

Experimentation is also used to test alternative theories or assumptions. Both monitoring and experimentation should be purpose-driven and scale-appropriate. For monitoring, the purpose and scale are driven by the individual project. For experimentation, the purpose may be to address issues of scientific interest, especially to investigate questions of scientific uncertainty or to test specific assumptions and relationships in the planning model. However, such experiments may need to be long-term, large-scale (depending on the purpose and questions or hypotheses to be tested--the appropriate scale issue), and costly. These longer-term experiments can easily suffer from the dilemma of the differences in time scales of sociopolitical issues and ecosystem responses: there may a push to change a decision through litigation or other means before the results are known. Therefore, it is unlikely that an organization can implement very many such studies, even if they are important.

On the other hand, local, smaller-scale studies need not necessarily be short-term, but do have the advantage of attracting local interest, can be driven by local information needs, and can be used to build "learning" or "adaptive" networks of local citizens who can work together in the face of uncertainty, and with differing values, to test their own

implicit and explicit assumptions about the system. It may be possible to use a reductionist approach to reduce the larger-scale questions into smaller, local experiments, while building a base of local "champions" for innovation and experimentation. In essence, the local groups begin to jointly own the problem—and by working together to solve specific issues, they develop a capacity to learn together and move forward.

Thus, both local- and landscape-level experimentation consistent with the study's objectives and purposes, and scale-appropriate monitoring based on those objectives and purposes, are crucial.

HOW ADAPTIVE MANAGEMENT DEALS WITH RISK AND UNCERTAINTY

In Chapter 3, on wicked problems, we introduced the principle of determinism (Kimmins 2003), which states that there is an explanation for every event or condition in the from of a set of antecedent conditions, factors, or determinants that collectively determine or cause the event. Any biological event involves at the very least two—most often several—major antecedents, known as multiple determinism. The importance of the principle of determinism in our case is that as the complexity of a condition or event's determinism increases, the probability of predicting the condition or event's occurrence decreases. That is, complexity leads to uncertainty.

According to Kimmins, "by understanding all of the antecedents in a complex, multiply determined event, we can effectively reduce it to a case of causal determinism as far as prediction is concerned" (Kimmins 2003). In causal determinism, a cause is an antecedent that is both necessary and sufficient to determine the event. Therefore, there is perfect prediction because of the one-to-one correspondence between antecedent and effect. "Through knowledge and understanding of forest ecology and of local forest conditions comes predictability of those forests. Through predictability comes the selection of ecologically and economically rational objectives and the best methods of attaining them" (Kimmins 2003).

Ecosystems, however, are far too complex to accurately predict future conditions (Bormann, Cunningham et al. 1994). Complexity is multiple interconnected relationships and levels from the biological perspective (Asher 2001). However, in the case of the Sierra Nevada, as in many natural resource issues, complexity also involves interconnected social and political issues. Does that mean doing nothing until the action's ramifications are fully known? Probably not, since doing nothing also has many unknown and poorly predictable results. "Complexity is confronted by increasing effort to understand mechanisms that influence change, by reducing expectations that the future can be accurately predicted, and by reducing risk through diversifying" (Bormann, Cunningham et al. 1994, p. 3). If uncertainty requires learning and adjustment, the need for adaptive management seems indisputable (Asher 2001).

In fact, uncertainty is central to the concept of adaptive management (Irvine and Kaplan 2001). Unlike conventional management practices, which may attempt to make precise predictions and presume certainty, adaptive management accepts as given the reality of

incomplete knowledge, and focuses on building learning opportunities into designing and implementing policies. Therefore, adaptive management emphasizes learning by doing, treating management actions and policies as hypotheses to be tested, and then designing them and implementing them to generate critical information about the resources being managed. Irvine and Kaplan (2001) describe four key steps:

- the assessment phase identifies specific goals for the natural resource being managed, such as desired future condition;
- the second phase identifies and assesses the significance of gaps in knowledge and generates alternative management actions;
- the implementation phase treats management actions as experiments; and
- the final phase uses the findings to revise policy as necessary.

In a review and critique of the adaptive management approach used in the Northwest Forest Plan, Stankey et al. (2003) highlight three critical aspects of adaptive management:

1. Adaptive management treats actions and policies as experiments that yield learning by mimicking the scientific method of specifying hypotheses, highlighting uncertainties, structuring actions to expose hypotheses to field tests, processing and evaluating results, and adjusting subsequent actions and policies in light of those results.
2. Rather than treating uncertainty and risk as a reason for precaution, adaptive management embraces them as opportunities for building understanding that might ultimately reduce their occurrence.
3. Effective adaptive management involves three elements: (a) producing new understanding based on systematic assessment of feedback from management actions; (b) incorporating that knowledge into subsequent actions; and (c) creating situations in which understanding can be communicated.

Managing complex biological and social ecosystems clearly involves risk and uncertainty (Johnson and Williams 1999). In most cases, risk and uncertainty result in caution, or no action, until more information is known. But acting in a risk-adverse manner can suppress the very experimental policies and actions that would produce the information needed to reduce such risk and uncertainty. It is problematic as to whether such protective approaches are preferable to experimentation as a way to safeguard endangered values (Stankey, Bormann et al. 2003). And, a consequence of failing to act adaptively in the presence of uncertainty is foregoing potential learning which might better inform future actions.

Asher (2001) points out the obvious: that adaptive management depends on good adaptations—and perverse learning patterns can lead to perverse adaptations. He identifies several ways in which perverse learning patterns can arise. First, they can develop as a result of oversimplification in the face of uncertainty. Or they can arise because the lessons ran counter to institutional interests: learning becomes perverse because it is institutionally convenient rather than valid (Asher 2001). "The persistence or resilience of the organizations entrusted with resource management may hinder their ability to reverse their own mistakes in resource policy or practice" (Asher 2001). Further, there is great risk that adaptation will be based on short-term considerations

reflecting the time horizons of agency personnel and institutional interests, such as reward systems and budget cycles. Finally, while these actions can result in precipitous adaptation, it is also possible for institutional constraints to restrict adaptation because an agency or its managers feel threatened by significant change. Or external decisions can override the interest-based conservatism of existing resource management agencies (Asher 2001). For this type of intervention to occur, there must be sufficient motivation on the part of external actors (including higher-level agency personnel) to undertake the effort—as well as the political risk—to change rules, organizational structure, or both.

No management system can eliminate mistakes, but adaptive management can shorten the time from recognizing a problem to correcting it, so that management reflects new societal demands or new research information (Bormann, Cunningham et al. 1994). Because both ecosystems and the public's collective values often change unpredictably, any management goal is not likely to last long. Therefore, a management approach that focuses on rapid learning to adjust to changing circumstances is likely to improve over the long term.

CASE STUDIES

To evaluate the use, success, and pitfalls of adaptive management, we review several seminal cases, each of which teaches crucial lessons:

- setting air quality standards in Great Britain (Stubbs and Lemon 2001);
- dealing with the threat of hydropower generation to salmon and steelhead in the Columbia River Basin (Lee 1989; McLain and Lee 1996; Smith, Gilden et al. 1998);
- regulating water flows and the threatened Florida Everglades (Gunderson 1999);
- seven adaptive management cases in riparian and coastal ecosystems (Walters 1997b; Rogers 1998);
- managing scarce groundwater supplies in and around Fort Huachuca in Arizona (Gen 2001);
- use of adaptive management by watershed councils in southwestern Oregon (Habron 2003);
- experimental flooding from the Glen Canyon Dam in the Grand Canyon (Meretsky, Wegner et al. 2000);
- managing waterfowl harvests in the U.S. (Johnson and Williams 1999);
- co-managing salmon fisheries in British Columbia (Pinkerton 1999);
- managing water projects in New South Wales, Australia (Gilmour, Walkerden et al. 1999); and
- Adaptive Management Areas (AMA's) provided for in the Northwest Forest Plan (Stankey and Shindler 1997; Stankey, Bormann et al. 2003; Thomas 2003a).

Air Quality Standards in Great Britain (Stubbs and Lemon 2001)

European air quality standards have been set by international negotiations within the European Union and the United Nations Economic Commission for Europe. In the United Kingdom (UK), proposals for a national air quality strategy focused on local

government as the level best able to provide an integrated management response. Local governments, however, were reluctant to take on this task without additional funding. However, because air quality issues cross boundaries of authority and responsibility, the UK legislation assumed inter- and intra-agency cooperation at scales from local to regional and national, without significant additional financial resources. Beyond organizational complexity were issues of the dynamic complexity of the processes affecting air quality phenomena and the problematic nature of linkages between air quality and public health.

Stubbs and Lemon (2001) chose to develop and study a process for adaptively implementing air quality regulations in the Bedfordshire County, UK. The study had two objectives:

1. to identify the network of individuals who had formal responsibility for, or who could make the most difference to, Bedfordshire's air quality; and,
2. to facilitate activities designed to share understanding between those individuals and highlight opportunities for coordinated action.

They used a reflective and adaptive research process that followed the philosophy "think of the other." This was manifest in a three-way focus: how actions were being felt by others, how things might be other than they appeared, and how theory and data were informing one another.

The process began by discovering the network. It was clear that the key groups were maintaining diverse, sometimes conflicting, interpretations of the process that generated what were widely accepted as central phenomena or issues relating to air quality. If stakeholder language is used in its broadest sense of clusters of shared interest and concerns, then stakeholders were defining issues, but issues were also defining stakeholders. Since the individuals concerned did not have a history of cooperation, Stubbs and Lemon placed initial emphasis on creating a climate that would foster a shared understanding of each other's positions and contributions through creative dialogue, i.e. learning from diverse perspectives (Senge 1990).

At the onset, a facilitated stakeholder face-to-face dialogue—in which the facilitator takes responsibility for creating and maintaining conditions that encourage exposing assumptions and judgments likely to invoke unquestioning, defensive behavior to be postponed—was used. Facilitators fostered a spirit of inquiry through such techniques as using a rule encouraging "yes, and how…" rather than "yes, but…" to help suspend premature judgment and the defense routines it triggers, so that ideas could be developed more fully. The strength of these techniques is in revealing diverse perceptions of the same issue to reach some level of consensus about that issue's complex nature. The process then continues using techniques that facilitate more radically exploring possibilities for collective action through creative thinking, especially "metaphor and synectics" (Gordan 1961). According to Gordon, synectics is a deliberate attempt to make the familiar strange so that creative suggestions can emerge and that "play with metaphor is one of the most fruitful of the mechanisms which can be used to make the familiar strange" (as quoted in Stubbs and Lemon 2001, p. 325).

> When used as a tool in facilitated stakeholder dialogue, alongside the "spirit of inquiry" techniques described earlier, it [synectics] appears to offer significant potential for building shared understanding of possible futures. It is the combination of the two that we call creative dialogue.

The process was conducted through a series of three workshops. Workshop 1, "Divergence," was to establish the spirit of inquiry. Workshop 2, "Convergence," used the concept of leverage (Senge 1990) to consider which problems highlighted in the first workshop could be influenced by carefully applied but relatively small, local actions. The facilitator asked the whole group to suggest local resources or decision-making structures that could be used to achieve actions identified as levers. Participants were then invited to work with their earlier groups to define a small, workable project that would improve air quality in Bedfordshire. Finally, in Workshop 3, "Sharing Mental Models" several individuals felt inspired to share data with a view to recognizing patterns therein and sharing individual appreciations of the processes underlying those patterns. Participants were then invited to suggest how the factors developed in the individual models were connected. Factors' range and interconnectivity were illustrated in a composite cognitive map constructed to summarize similarities in individual models of underlying processes shared during the meeting.

As Stubbs and Lemon (2001, pp. 328-329) concluded,

> Critical appreciation of the interests, concerns, and capacities for action of different stakeholder groups, gained through networking and creative dialogue, helped hone a sense of audience for those touched by the issue under investigation. However, that sense of audience both emerged from and drove the processes of networking and creative dialogue. These concepts and the interconnections between them can be represented as constituent parts of a larger process brought into focus by the study's central interest in responses to complex transboundary issues. When the case is viewed in these terms it becomes apparent that the outcome of that larger process is an adaptive response network. In effect, this is a virtual organization of stakeholder representatives with an enhanced capacity for joined-up thinking.

This case demonstrates a successful "adaptive response network," similar to adaptive collaborative management, through facilitated stakeholder dialogue deliberately aimed at reaching consensus through creative thinking.

The Columbia River Basin and Pacific Salmon (Lee 1989; McLain and Lee 1996; Smith, Gilden et al. 1998; Lee 2001)

Adaptive management was initially adopted in 1984 by the Northwest Power Planning Council as a way to organize the council's activities to protect and enhance Pacific salmon in the Columbia River basin. Those efforts were diverted in 1990 by litigation under the Endangered Species Act, so that the Columbia Basin's experimental program phase did not get very far (Volkman and McConnaha 1993; Lee 2001).

The Northwest Power Planning Council has a major role in dealing with salmon issues in the Pacific Northwest. Kai Lee was a member of the Council from 1984 to 1987, and introduced the Council to the concept of adaptive management. Lee (1993) used a metaphor of "compass and gyroscope" for integrating science and democracy. According to Lee, science is linked to human purpose as a compass, "a way to gauge directions when sailing beyond the maps." Democracy is a way to maintain our bearing through turbulent seas—the gyroscope. The compass, grounded in the scientific method, warns when the direction is off course, while the democratic process's bounded conflict lends stability when humans encounter turbulence in their relationships with nature. Unfortunately, "the scientific compass often points in more than one true direction, and the public gyroscope tilts precariously with political turbulence"(Smith, Gilden et al. 1998) .

The life cycles of salmon and steelhead are complex, and involve the Pacific Ocean, coastal estuaries, inland rivers and small streams. Both live most of their lives in the ocean but return to fresh water to spawn. Adult salmon die after spawning, while steelhead return to the ocean. Declining populations of both have been attributed to over-harvesting, loss of spawning and rearing habitat, and high mortality during migration downstream through the many hydroelectric power-producing dams along the Columbia River and its major tributaries.

These fishes' complex life cycles, the uncertainty of scientific data, the resources' value to many different stakeholders, and multiple stressors creates a situation where conflicts abound and blame-shifting is common. In 1991 the Endangered Fisheries Committee of the American Fisheries Society found that 214 naturally spawning stocks were depleted (Smith, Gilden et al. 1998). To cope with this situation, an adaptive management strategy was adopted. Groups of scientists, federal and state agencies, scientific societies, Native American tribes, and nongovernmental organizations have tried to identify the scientific principles for dealing with the problem. Seven management paradigms, each with its own key concept, have evolved from this effort: "pristine," "virtual," "normative," "ecosystem," "recovered," "restored," and "rehabilitated" (Smith, Gilden et al. 1998). The approaches overlap somewhat, but each stresses a unique vision for guiding management. These competing concepts show that scientists are providing a variety of compass headings. At the same time, three studies of manager, user, and public perceptions of the salmon problem mentioned by (Smith, Gilden et al. 1998) suggest that the public, users, managers, and scientists do not see the causes of salmon decline in the same way.

Scientists involved in the salmon issue have tried to be both compass and gyroscope, thereby confusing their roles and public perceptions of their findings: scientific results are being used by the various stakeholders to support many different positions and paradigms (Smith, Gilden et al. 1998). Where experts see convergence among the various scientific conceptual approaches, the public only sees competing scientific findings and conclusions. Because more is invested in conducting science than in communicating the results of scientific inquiry, especially in ways that can be understood and accessed by the lay public, the result is often a limited public understanding of the available

knowledge and/or its limitations. Members of the public say they have useful knowledge and want to be involved, but only if they believe that they can influence decisions (Smith, Gilden et al. 1998). Smith, Gilden, et al. (1998, p. 679)conclude that public involvement in the Pacific Northwest salmon issue is inadequate: "Too often, public participation merely fulfills a legal requirement rather than helping to improve decision making."

The Columbia River Basin adaptive management effort was initially successful as a result of strong leadership by the Northwest Power Planning Council and available funding for experimentation through an annual rate-payer assessment on power usage (Lee 1989; McLain and Lee 1996). However, in the end, litigation from failing to reach agreement on the nature of the issue among the various stakeholders led to listing specific genetic strains of anadromous fish as Endangered Species. Thus the breakdown of adaptive management limited accomplishment.

In the end, litigation from failing to reach agreement on the nature of the issue among the various stakeholders led to listing specific genetic strains of anadromous fish as Endangered Species…resulting in limited accomplishment.

The Florida Everglades (Gunderson 1999)

Gunderson (1999) follows the concepts of adaptive environmental assessment and management (AEAM) as initially described by Holling (1978). Gunderson believes that a predicate of AEAM has often been searching for flexibility in management institutions, or for resilence in the ecological system, prior to structuring actions designed for learning. Many obstacles to AEAM occur, then, when there is a lack of flexibility in the power relationships among stakeholders, or when there is little or no resilience in the ecosystem.

Resource managers continually deal with uncertainty by assuming it away; by seeking what Gunderson (1999) calls "spurious certitude, that is, to break the problem or issue into trivial questions spawning answers and policy actions that are unambiguously 'correct,' but, in the end, are either irrelevant or pathologic"; by replacing the uncertainty of resources issues with the certainty of a process, such as a new policy, regulation or lawsuit, or a new institution such as a technical oversight committee or science advisory committee; or by confronting the uncertainties directly through AEAM.

Based on the literature and experience in dealing with nutrient enrichment and water flow issues in the Florida Everglades, Gunderson (1995; 1999) believes that "if there is no resilience in the ecological system, nor flexibility among stakeholders in the coupled social system, then one simply cannot manage adaptively" (Gunderson 1999). In co-evolving human and natural systems, surprises are the rule, not the exception. Gunderson (1999) identifies three types of surprises:

"If there is no resilience in the ecological system, nor flexibility among stakeholders in the coupled social system, then one simply cannot manage adaptively." (Gunderson 1999)

1. local surprises created by broader-scale processes for which there is little or no previous local knowledge, which can be resolved by broader-scale observation and an historical knowledge accumulation;
2. cross-scale surprises that are similar to local surprises, but differ in that larger-scale fluctuations intersect with slowly changing internal variables to create an alternative stable local system state and are often the source of policy crises (Gunderson, Holling et al. 1995); and
3. genuine novelty—the case of something truly unique—in which new variables and processes transform the system into a new state.

In the latter case, little or no experience exists for either understanding the transformation or structuring management actions.

While ecosystem responses can be characterized by surprises, they also are known to be resilient. Holling (1973) was first to distinguish two ways for describing resilience based upon different assumptions of *equilibria* and *dynamics*. The more common definition assumes that ecological systems operate at or near a *global equilibrium*, so resilience is the ability to return to an equilibrium following a disturbance, quantified in terms of return time. This definition focuses on efficiency, constancy and predictability. *Dynamics* emphasizes conditions with more than one stable equilibrium, where instabilities can move a system into another regime of behavior, so resilience is measured by the magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behavior.

The basic difference in these two views lies in whether or not the existence of multistable states is assumed. If only one stable state exists or can be designed to exist, then the only possible definition and measures for resilience are near-equilibrium ones, such as characteristic return time. However, nature often has multiple equilibrium states (Gunderson 1999). When shifts occur between alternative states or conditions, they are usually taken as a resource crisis. If they are viewed as a crisis, then understanding how and why people choose to react is key to managing for resilience (Gunderson 1999).

> When faced with shifting stability domains and corresponding crises, management options fall into one of three general classes of response. The first is to do nothing and wait to see if the system will return to some acceptable state, while sacrificing lost benefits of the undesirable state and often spending lots of money on piecemeal research. The second option is to actively manage the system and try to return it to a desirable stability domain. The third option is to admit that the system is irreversibly changed and, hence, that the only strategy is to adapt to the new, altered system. The resilience of the system provides the ability to cope or adapt in a world characterized by crises and shifting stability domains, and for managers to affordably fail and learn…. (Gunderson 1999)

In the late 1980s, growing appreciation of a number of significant chronic resource issues in the Florida Everglades resulted in a series of workshops and a symposium to synthesize information about the ecosystem. Known problems included declining wading nesting bird populations, changes in vegetation patterns due to nutrients and water management, changes in aquatic communities, declines in fisheries, and increases

in populations of exotic organisms. Carl Walters and Buzz Holling were asked to help integrate and synthesize parts of the system.

Over a two-and-one-half year period, they held a dozen workshops involving 50 technical professionals that transformed the system's management understanding. One product included a controversial computer model (Walters, Gunderson et al. 1992) that simulated key ecosystem components' spatial and temporal dynamics. Submodels were developed for hydrologic dynamics and for a set of ecological interactions among the hydrology and vegetation, aquatic organisms, alligators, and wading birds. Based on comparison with historical data, the hydrologic model gained credibility, but the ecological submodels were thought to not be credible because ecological processes that occur on a finer spatial and temporal scale could not be aggregated to the scale of the hydrologic model. This led to developing new models based on aggregating individual dynamics.

The major conclusion of the informal, collaborative effort among professionals was that enough was known about the Everglades ecosystem to begin restoration and resolving chronic issues. A new vision for ecosystem restoration was developed by six people, each having technical roles in management agencies and academic institutions. Despite this small group's informal relationship, they used interaction, along with their individual system understandings, to build an integrated strategic overview. This view developed into a wider, shared vision in two stages. The first stage compressed and translated the technical understanding into a format understood by a broader audience, accomplished in two formats: a computer "movie" or animation of the Everglades system's water dynamics, and creating "fact" sheets: one-page documents discussing what is known and not known about a key issue. The second stage communicated this understanding to a wider audience through individual meetings with board members of the South Florida Water Management District and in a workshop with a broad range of stakeholders. However, none of these processes sought active adaptive management.

As of the date of Gunderson's assessment (Gunderson 1999), many adaptive management policies have been recommended, but none have been implemented. Workshops specifically designed alternative water management experiments that would help to provide information for dealing with resource issues, but no direct experimentation has been adopted. The failure to pursue adaptive management was attributed to three causes:

Adaptive management cannot be applied when the risks of failure are socially and legally unacceptable.

- no flexibility in the social system,
- little or no resilience in key components of the ecological system, and
- technical challenges with designing experiments.

The arrangement among stakeholders and management agencies was not very flexible, and bureaucratic management agencies seemed to be trapped by narrowly interpreting their legal mandates. Stakeholders who benefit from the current management system were able to block implementing alternative management regimes, and real and threatened lawsuits indicate little policy versatility. Finally, there was not much room to experiment with certain resource issues. For example, in the Everglades' low nutrient/low productivity ecosystem (oligotrophic), very small changes in nutrient

concentrations result in dramatic shifts in vegetation stability. Adaptive management cannot be applied when the risks of failure are socially and legally unacceptable.

> A central tenet of AEAM is learning. Yet, if policies are working or appear to be working, there is little or no emphasis on learning. It is only when policies fail that learning is deemed necessary and given a priority. The challenge to develop a capacity for learning continues to be problematic among most resource institutions.
>
> Learning is a long-term proposition that requires a ballast against short-term politics and objectives. More emphasis is needed on development of sustaining foundations for dealing with complex resource issues. Another shift will probably require a change from management by objectives and determination of optimum policies, toward new ways to define, understand, and manage these systems in an ever-changing world. That focus should not be solely on variables of the moment (water levels, population numbers) and their correlative rates, but rather on more enduring system properties such as resilience, adaptive capacity, and renewal capability. This framework involves both the human components of the system (operations, rules, policies, and laws) and the biophysical components of the landscape and its ecosystems…. [**U**]**ntil management institutions are capable and willing to embrace uncertainty and to systematically learn from their actions, adaptive management will not continue in its original context, but will be redefined in a weak context of "flexibility in decision making."**
>
> **In cases of successful adaptive assessment and management, an informal network seems always to emerge. That network of participants places emphasis on political independence, out of the fray of regulation and implementation, places where formal networks and many planning processes fail. The informal, out of the fray, shadow groups seem to be where new ideas arise and flourish. It is these "skunkworks" who explore flexible opportunites for resolving resource issues, devise alternative designs and tests of policy, and create ways to foster social learning.** (emphasis added) (Gunderson 1999)

As noted above, many barriers to adaptive management occur when there is little or no resilience in the ecological components, or the extant power relationships among stakeholders lack flexibility. In these cases, a pragmatic solution is often to seek to restore resilience or flexibility, rather than to pursue adaptive management. But building understanding, and diagnosing ecological resilience and institutional flexibility, are key roles that adaptive management can perform. If resilience is not defined during an assessment, then it may be possible to discover it through a series of smaller-scale experiments.

> In spite of obstacles, AEAM still remains an antidote to current ecosystem management approaches that seek spurious certitude in science and social processes. AEAM has been shown to be effective in the resolution of multiple competing hypotheses around resource issues. It can change the ways in which management institutions assess resource issues, can nurture and test new theories,

> and can establish new ways of communicating among scientists, policy makers, and stakeholders. By helping to understand ecological resilience and seeking institutional flexibility, AEAM will continue as a useful approach to resolving complex resource issues into the next century. (Gunderson 1999)

Understanding institutional flexibility seems to be both a challenge and a key to unlocking a wider range of chronic management pathologies. This case demonstrates challenges to "adaptive environmental assessment and management"—similar to adaptive collaborative management—in the forms of stakeholder and management agency inflexibility, little or no resilience in the ecosystem, and powerful stakeholders with competing interests. But, with careful integration, AEAM can successfully resolve multiple competing hypotheses around resource issues, can nurture new theories, and can establish new communicative avenues.

Adaptive Management in Riparian and Coastal Ecosystems (Walters 1997b; Rogers 1998)

Walters (1997b) argues that adaptive management should begin with an effort to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to predict alternative policies' impacts. A necessary second step is to design management experiments to test these models. The modeling step may allow managers to replace costly learning by trial and error (an evolutionary process) with learning by careful tests (a process of directed selection).

However, few efforts in adaptive management planning have proceeded beyond the initial step of model development to field experimentation. Walters (1997b) has participated in 25 planning exercises for adaptive management of riparian and coastal ecosystems, but only 7 of these resulted in relatively large-scale management experiments—and only 2 of those would be considered well-planned in terms of experimental design. In two other cases, he could not identify experimental policies that might be practical to implement. The remainder of the 25 cases have either ended with no visible product, or are trapped in an endless process of model development and refinement.

Based on his experience, Walters (1997b) describes four reasons for low success rates in implementing adaptive management policies:

1. *Modeling for adaptive management planning has often been supplanted by ongoing modeling exercises, apparently based on the presumption that detailed modeling can substitute for field experimentation to define best management practices.* In seven cases he examined, initial model development was followed by substantial and continuing investment in baseline information gathering and complex simulation modeling. What seems to drive these continuing investments is the presumption that sound predictions (and, thereby, good baseline policies) can be found by looking more precisely, i.e. in more mechanistic detail, at more variables and factors. Walters

> Complex models must be tested against careful field experiments.

(1997b) is pessimistic that modeling can substitute for field experimentation for several reasons:

a. Cross-scale linkages: The most technical issue in developing and using models has been the cross-scale linkage between physical/chemical and ecological processes. Physical models create an enormous computational burden in running the linked, overall model for longer ecological time scales such as years and decades. Decoupling the models and running them independently can reduce computational difficulties, but makes it difficult to test sensitivity and to search for better management policies. In the end, not much is learned by "grinding out a few, very detailed management scenarios and comparing them using various quantitative indicators" (p. 4). Complex models must be tested against results of careful field experiments.
b. Nonadditivity of parameter and data effects in population dynamics analysis: It can be expected that more detailed models are less prone to make bad predictions due to errors in estimating any one model parameter, since each parameter relates directly to a smaller part of the overall population structure. It also would seem that when many kinds of data are used to estimate model parameters, the population dynamics assessment should be less sensitive to assumption errors about how to interpret or use each observation. In fact, population dynamics models typically involve sequential products—not sums—of production and survival factors; when any one number in a product is wrong, the whole product is affected proportionally.
c. Difficult and emergent processes: Modeling for adaptive management planning always reveals substantial gaps in knowledge about key processes and functional relationships, especially when directed at predicting specific policy options' impact(s). Specific causal linkages involved in such predictions often concern biophysical relationships that have not been of interest to scientists or have escaped investigation by traditional scientific methods. Such relationships often describe events' and interactions' "emergent" effects that accumulate over relatively large space and time scales. Analyzing historical and comparative data are generally part of the model development process, but almost never provide the range and resolution of data needed. Large-scale field experiments aimed at particular processes and relationships are becoming more popular in ecology, but have proven technically very difficult.

   > An emergent principle of adaptive management is that, for every difficult functional relationship, there is a scientist willing to claim the ability to measure it for you if you will provide enough research money to measure details of how the relationship arises. (p. 7)

d. Confounding of factor effects in historical validation data: Modelers may not distinguish between a "valid" model (one that is consistent with, or fits, historical data) and one that makes correct predictions. It is common to find wide-ranging alternative models that are equally valid, but make

very different predictions about factors whose effects are confounded in the historical record (factors that have varied together over time).

2. *Effective adaptive management experiments have often been seen as expensive and/or ecologically risky, compared to best management practice baseline options.* Adaptive management can be expensive, especially if it involves large-scale field experiments. Increased costs begin with developing the models needed to define clear hypotheses and policy options, followed by substantial costs to implement experimental options. Additional costs are associated with monitoring programs. Finally, manipulative experiments always increase at least some ecological risks. Methodology for objective, economic comparison of experimental management options is not well developed, and there is no general consensus about how to value or weight possible experimental outcomes. There are cases in which experimental management scale changes needed to resolve key uncertainties would be unacceptably costly or risky:
    a. Direct costs to riparian interests: Some proposals for experimentally manipulating or restricting water uses would be costly to economic interests. Unfortunately, there is no simple, objective way for economic interests to decide whether the odds of being forced into radical change are high enough to justify switching to a cooperative experimental approach.
    b. Intergenerational trade-offs: Since ecological responses to experimental management regimes generally occur over a wide range of time scales, most management experiments involve a strong element of intergenerational value trade-off. Treatments initiated today generally have substantial costs to present resource users, but the legacy of response information will mainly be useful to the next generation's managers and users.
    c. High monitoring costs: Well-designed management experiments can have high monitoring costs, and ecosystem management objectives often result in demand to monitor a far broader set of response variables. Developing affordable monitoring programs for adaptive management may involve substantial, scientifically risky innovation in methods and approaches.
    d. Risk to sensitive species: Management experiments in settings like the Florida Everglades have been considered risky for sensitive species, i.e. those with very specialized habitats. There is no assurance that experiments designed to restore natural habitat structure will enhance particular habitat types within the overall structure. However, this issue is one of comparative risk: Baseline or default policies are often highly uncertain in the protection that they would provide for sensitive species. Often the best justification for experimenting is lacking a clear best course of action.
    e. Misunderstandings about experimental design options and opportunities: Many consider modeling and experimentation as distinctive. However, to interpret or measure any response to treatment, the experimenter must engage in modeling: somehow predicting what would have happened had treatment not been applied. In standard research designs, measures of control or reference experimental units are used to model what would have

happened. In before–after comparisons on single systems, the "before" behavior is used to predict what would have happened.

According to Walters (1997b), there is no reason to believe that spatial predictors (spatial controls) are much better than temporal ones, except in rare settings where representative predictions can be "guaranteed" by deliberately selecting a large number of both treatment and reference units, at random, from a large universe of units. Given that it is often difficult or impossible to practice randomization in ecological experiments, the experimenter may resort to using the best model possible to predict what would have happened. If modeling is considered an integral part of experimentation, then it is possible to consider a broader range of design options and methods for predicting responses. Using experimental modeling also suggests that there is no risk-free experiment: predictions of what would have happened without treatment can be wrong no matter how those predictions are made.

3. *There may be strong opposition to experimental approaches by those protecting various self-interests in management bureaucracies.* Almost any management proposal or change is threatening to at least some organizational group or interest. Complex management settings especially seem to result in large research investments, both because scientific work offers a possibility of certitude in decision making, and because "more research is needed" is a convenient answer in situations where bureaucratic and administrative interests are best served by delaying hard management decisions. According to Walters (1997b), at least three organizational factors prevent implementing experimental opportunities: believing that pretense of certainty is necessary to maintain agency credibility; promoting process research approaches by scientists; and inaction as a rational choice by bureaucratic decision makers.

At least three organizational factors prevent implementing experimental opportunities: believing that pretense of certainty is necessary to maintain agency credibility; promoting process research approaches by scientists; and inaction as a rational choice by bureaucratic decision makers. (Walters 1997b)

4. *Deep value conflicts within the community of ecological and environmental management interests prevent policy change*.

   Stakeholder involvement processes have often revealed considerable flexibility and constructive attitudes from "development" interests (power producers, transportation interests, consumptive water users), but intransigence and bickering among interest groups representing different "ecological" values. Conflict among ecological interests has been particularly intense where historical development has created "new" ecological values…. There is considerable danger that administrators and politicians will seek to deal with conflicting ecological values by employing compromise restoration policies, based on the presumption

> that there is a smooth trade-off between hydrologic restoration and species response. (Walters 1997b, p. 16)

In response to Walters, Rogers (1998) argues that the problem is divergent operational philosophies and reward systems. Scientists have a propensity to seek intellectually difficult problems rather than immediately useful ones, while managers are driven by their institutional hierarchy's pragmatic needs. Each group needs to adopt these approaches among their peers, but they must find common process and purpose when working together. Rogers addresses what he sees as three problem areas:

1. *Ecology is not serving management well, and adaptive management is not being accepted and applied in practice.* A fundamental premise of adaptive management is that managing by experiment is a way in which scientists have tried to make science useful. Rogers speculates that the problem may arise because the approach tries to make scientists out of managers and managers out of scientists. It would be better to recognize the divergent operational philosophies and build an effective interface that promotes and supports a lasting science/management partnership. This interface should be built on sound principles of technology transfer, which recognize that the problem has not been solved until management's desired end point has been met. Too often adaptive management is reactive to crisis management due to lacking commitment to a clear goal. Solutions must deal with two misconceptions:

   > Build an effective interface that promotes and supports a lasting science/management partnership, which develops consensus on institutional purpose, culture, and structure, and neutralizes adverse consequences of divergent operating philosophies and reward systems. (Rogers 1998)

   a. That scientific products have intrinsic value, and that the best possible product must be developed if it is to influence user choice. In reality, the client determines value, and choice is determined by what is good enough to do the job.
   b. That the technology's power determines its success. In reality, it is often the infrastructure required to support the technology that determines its success.

   Scientists may pursue the ultimate model while managers may fall into a comfort zone of "best use policies" and "passive adaptive use of improved monitoring," rather than adopting a truly experimental approach. The scientist/manager partnership should develop consensus on institutional purpose, culture, and structure, and neutralize adverse consequences of divergent operating philosophies and reward systems (Rogers 1998).
2. *Inaction is a comfortable option for managers.* Rogers agrees with this issue as identified by Walters (1997b). He believes that the problem's root is that too few scientists and managers spend enough time in collaborative efforts to unambiguously define the end points or desired conditions of the system being managed. The idea of aiming management at desired end points may seem counter to adaptive management, but experiments can be conducted to determine the best path toward that end point. The value of defining the end point is that the partners have a common goal.

3. *Monitoring becomes too expensive for management to implement.* By Rogers' (1998) definition, a goal is not a goal unless some indicator can be monitored, and attaining the goal is audited within the institution's resource constraints. Pragmatism is essential in designing a set of achievable ecosystem end points, and criteria with which to measure their achievement. If consensus can be achieved at one step, then it is possible to enter an iterative, adaptive management cycle in which both science and management can learn and improve their contributions' depth and rigor together.

Walters' and Rogers' extensive research details several barriers to successful ecosystem adaptive management. Walters sees it as a science-driven process that needs better management models, while Rogers counters that scientists and managers have to make concerted efforts to collaborate. Both seem to minimize the importance and engagement of other stakeholders.

Fort Huachuca (Gen 2001)

Applying adaptive management in a military environment presents special problems. At Fort Huachuca, in southeast Arizona's upper San Pedro River basin, water is a scarce resource and defines many of the area's socio-ecological problems. The river's surface water is needed to support riparian habitat, while groundwater is needed to support human activities in the basin. The groundwater supply appears to be abundant for human demands, but the current draw is diminishing surface water in the river, thereby threatening the riparian habitat.

There are two central tensions in using adaptive ecosystem management at military installations. First, there appears to be a inherent conflict between the ecosystem management objectives and the military mission. Second, conflicts exist between the military's bureaucratic decision-making processes and the open, democratic decision-making processes of adaptive ecosystem management. Gen (2001) examined Fort Huachuca's progress in implementing adaptive management concepts using three broad criteria: its democratic process in decision making, its ecological focus, and its adherence to 10 guidelines outlined by Department of Defense policy regarding implementing ecosystem management on military lands.

Fort Huachuca's military leadership has informed its decision-making process in two significant ways. First, they implemented socio-ecological modeling to aid in identifying potential future states of the river basin. Stakeholder participation has been integral in identifying alternative desirable states and those stakeholders' values and priorities. From stakeholders' inputs, the study's implementers described the alternative futures and their implications for current actions. Fort Huachuca has also engaged in significant community involvement, largely through quarterly meetings of the Fort Huachuca Conservation Committee. This regular meeting among military officials and area stakeholders addresses environmental issues affected by the Fort.

While decision-making authority remains with the Installation Commander, there is a broad opinion—but not consensus—that the post's personnel are sincere in considering public input, and incorporate it in their decisions when possible. However, there is a significant perception by several stakeholders that Fort Huachuca's efforts fall far short of stakeholder expectations. This partly arises from the requirement that Installation Commanders are obligated to adhere to higher military authority. For example, local decisions about desired futures were overridden when the Base Realignment and Closure Commission required Fort Huachuca to absorb specific Army units from other bases that were being closed. Thus, while local stakeholders in the upper San Pedro River basin were calling for reduced water use, Fort Huachuca was obligated to implement expansions decided by national military policy makers. This led some local stakeholders to view the Fort's public involvement efforts as moot and to conclude that litigation is the only effective mode of influence.

Fort Huachuca's commitment to considering multiscalar ecological dimensions is evident in its implementation of water conservation measures and a water recharge program within the post. At the watershed level, the Fort actively participates in the Upper San Pedro Partnership and other regional ecosystem management efforts. The Fort must also develop an ecological monitoring program on the land it affects.

Finally, Fort Huachuca has made significant progress implementing Department of Defense ecosystem management guidelines. However, a major barrier to full implementation is the lack of vertical integration in the Army's policies, resulting in situations where policies affecting ecosystem management are outside local control.

Gen (2001) identified two areas of improvement based on his assessment of Fort Huachuca's implementation of adaptive ecosystem management. First, it must develop a decision-making process that integrates its bureaucratic structure into its stakeholders' democratic arena. As long as any military decision makers are absent from local discussions, the area's stakeholders will have legitimate cause to view the Fort's outreach efforts as little more that a polite gesture, as national military leaders make decisions that override local interests. Second, Fort Huachuca must develop and specify a decision-making process with its stakeholders, that is "deciding how decisions will be made." This cooperation addresses the need to delineate how public input will be gathered, assessed, and used in decisions. Further, a defined process would give both military and local stakeholders clear expectations of how public input can influence military decisions. In the absence of such specification, stakeholders may choose to use more confrontational modes of influence such as litigation and political intervention.

Despite actively involving the local community, higher levels in the responsible organization overrode adaptive management initiatives—which in turn alienated local stakeholders. Thus, to be successful, adaptive management must engage all ultimate decision makers in the collaborative process.

Watershed Management Councils in Southwestern Oregon (Habron 2003)

Watershed management councils have been established in many parts of the western U.S., especially in California, Oregon and Washington. Oregon's watershed councils began as a reaction to concern regarding losing migratory salmon (Habron 2003). Other councils established in Oregon address agricultural and watershed issues (the Oregon Watershed Improvement Coalition in eastern Oregon) and forest management issues related to northern spotted owl management (the Applegate Partnership in southwestern Oregon). The State of Oregon supports these councils providing they follow guidelines for council formation, including strong evidence of diverse interest group representation and official recognition by a local government entity. The state-run Oregon Watershed Enhancement Board (OWEB) provides technical and financial resources, and bases its funding decisions on the existence of a sound watershed assessment and on priorities defined by OWEB's advisory board. The Pacific Northwest Power Planning Council also emphasizes the need for watershed assessment and prioritizing conservation projects. The State of Oregon officially recognizes watershed councils as the preferred local alternative to federal planning to address the state's decline in salmon and water quality.

The Umpqua Basin Watershed Council (UBWC) was authorized by Douglas County, Oregon, in March 1997. Its 16-member management committee is appointed by Douglas County Commissioners. The members represent various stakeholders, including agriculture, timber, aggregates or mining, fishing or conservation, urban or public utilities, and Douglas County. There is also one member-at-large. The council meets monthly using a consensus decision-making framework: any management committee member can block a decision by expressing disagreement. The council has a full-time coordinator and shares two biologists' positions with the Oregon Department of Fisheries and Wildlife and the Oregon Wildlife Heritage Foundation.

According to Habron (2003) there are five main themes identified by the UBWC: (1) reducing bureaucracy; (2) fostering productive stakeholder discussion and understanding; and providing (3) financial, (4) technical, and (5) coordination support. The council also takes a "fast track" approach using what has been called the Bradbury process (Bradbury, Nehlsen et al. 1995), based on a handbook for prioritizing watershed restoration and recovery projects.

A case study of the UBWC's operation supports findings from other studies that watershed councils provide a setting to mix science and diverse public values, and that they also illustrate the success of and constraints to successful collaboration (Habron 2003). The study also suggests that for watershed councils to provide the institutional link to implement adaptive management, they must adhere to adaptive management's key steps: problem identification, brainstorming, modeling,

For watershed councils to provide the institutional link to implement adaptive management, they must adhere to adaptive management's key steps: problem identification, brainstorming, modeling, planning, experimenting, monitoring, evaluation, and changing behavior. The important tenets that underpin these steps are diversity, failure, risk, surprise, uncertainty, anticipation, feedback, flexibility, and learning. (Habron 2003)

planning, experimenting, monitoring, evaluation, and changing behavior. The important tenets that underpin these steps are diversity, failure, risk, surprise, uncertainty, anticipation, feedback, flexibility, and learning (Habron 2003).

The five themes identified by the council represent adaptive management's problem identification stage, and the council's activities provide an opportunity to resolve the five related problems. These themes also serve as criteria to evaluate council function: For the council to succeed and thrive, it must continually address these themes. Identifying issues (themes) provides challenges and opportunities for successfully implementing adaptive management. Further, attempting adaptive management without understanding critical factors and processes within the community fails to achieve adaptive management's promise (Habron 2003). Adaptive management and identifying and adhering to the themes relate in a symbiotic fashion: neither process—adaptive management and the council's success—can proceed without the other. Unfortunately, the Umpqua Basin has a significant number of private landowners who express a certain amount of ambivalence toward the concept of locally based watershed councils, resulting in a lack of accepting and using adaptive management.

Study results indicate that explicitly adopting community-based adaptive watershed management promises increased linkages between watershed conservation goals and private landowner concerns. But adaptive management holds promise only as long as it fits within the appropriate institutional mechanism that accommodates all watershed actors' needs. The key challenge for the UBWC is to adopt adaptive management. Yet, the study suggests that the council did not view watershed projects as opportunities for learning, nor did it acknowledge the possibility that science and research can fit with on-the-ground restoration projects. "Without significant council use and participation, adaptive watershed management in watersheds dominated by private lands holds little promise and only continues the current trend of incomplete adaptive watershed management in the Pacific Northwest" (Habron 2003).

The UBWC's unsuccessful attempt to implement adaptive watershed management highlights the power of private property stakeholders with little long-term interest in an ecosystem to co-opt management strategies.

Glen Canyon Dam (Meretsky, Wegner et al. 2000)

Adaptive management seeks to sustain ecosystems while using the associated natural resources. The goal of endangered species management under the Endangered Species Act is limited to protecting and recovering designated species, and the Act takes precedence over other policies and regulations guiding ecosystem management. The presence of endangered species can, therefore, limit options for ecosystem management and result in conflicts between the safest course of action to protect endangered species and the desired course of action for the ecosystems in which the species are found. The Grand Canyon ecosystem has been significantly affected by

Adaptive management seeks to sustain ecosystems while using the associated natural resources.

constructing the Glen Canyon Dam, specifically by reducing or eliminating natural flood cycles. An adaptive management experiment was used to study the effectiveness of high-volume controlled releases from the dam to simulate natural flooding effects in the downstream environment.

An important conclusion of the Glen Canyon Environmental Studies program was that the Grand Canyon river system had developed in a highly variable environment—which was significantly altered by constructing the Glen Canyon Dam. The Environmental Impact Statement (EIS) on the dam's operations concluded that traditional management methods were inadequate to compensate for the magnitude of environmental impacts to the Colorado River ecosystem, and recommended an adaptive management approach. An experimental flood using releases from the dam was planned to mimic floods that occurred annually before the dam was built. At first, no negative impacts were expected, and most species were expected to benefit. However, predicted damage to the Kanab ambersnail's terrestrial habitat brought the adaptive management proposal into direct conflict with endangered species management.

The Kanab ambersnail (KAS) was previously known from only two sites in southern Utah, and was believed to have been eliminated from one of those. It was listed as endangered in 1992 on the basis of the small number of known populations. A KAS working group consisting of members of the Arizona Game and Fish Department, Glen Canyon Environmental Studies, the U.S. Fish and Wildlife Service, and the U.S. National Park Service, was organized in response to the listing.

Vasey's Paradise, a small patch (> 0.25 ha) of riparian vegetation below a limestone spring along the Colorado River below the Glen Canyon Dam, is the only protected habitat for KAS because it occurs within the Grand Canyon National Park. Photos taken before closing the dam in 1963 show that spring flooding scoured vegetation back, controlling the lower limit of KAS habitat. After dam closure halted annual flooding, vegetation cover increased by 40% down to the lower water level associated with dam operations. After releasing the draft EIS on Glen Canyon dam operations in 1994, the U.S. Fish and Wildlife Service issued a Biological Opinion that set a permissible level of impact on KAS habitat below which the U.S. Bureau of Reclamation (the Bureau) could operate the dam without additional consultation. If flows from the dam resulted in destructing more than 10% of occupied habitat, the Bureau was required to cease operations causing habitat damage until consultation was complete.

The environmental assessment of the experimental flood predicted that as much as 17% of the KAS habitat might be destroyed. This set up a potential conflict between the equally desirable goals of trying to return more natural flood cycles to the Colorado River system within the Grand Canyon, and protecting the Kanab ambersnail. The Bureau entered into formal consultation with the U.S. Fish and Wildlife Service to determine whether the experimental flood could proceed. Recognizing the overall benefits of the flood and stressing the need to protect KAS habitat, the U.S. Fish and Wildlife Service developed reasonable and prudent measures to mitigate impacts to KAS. An agreement between the U.S. Fish and Wildlife Service and the Bureau required that 90% of the

snails in the area below the worst-case high water line be relocated above that line, and that the Bureau monitor the site to determine the actual take level. The Bureau was also to monitor for one year after the flood to determine KAS population and habitat recovery.

On-site estimates of KAS population size were substantially higher than counts from the previous fall, probably as a result of an exceptionally mild 1995-1996 winter. Finding and removing active snails required damaging but not destroying much of the vegetation below the worst-case flood line. However, finding and removing dormant snails required removing all vegetation and the associated rootmat in which the snails lay dormant. Therefore, the U.S. Fish and Wildlife Service required that researchers destroy 90% of the vegetation associated with the worst-case scenario, even though flooding might not rise to worst-case levels. Further, stripping this much vegetation would prevent researchers from leaving patches of vegetation to determine the plants' ability to withstand the flood's force.

The combination of higher population numbers and potential additional damage to the KAS habitat were made known to the U.S. Fish and Wildlife Service biologist charged with writing the mitigation requirements. The following day, the Fish and Wildlife Service issued amended reasonable and prudent measures, directing that 75% of snails be relocated from 50% of the worst-case inundation zone. Monitoring requirements remained that same. This change gave the Working Group latitude to leave habitat in the error zone above the predicted flood elevation, and to leave small amounts of vegetation below the anticipated flood elevation. The changes allowed a further experiment in which some areas near the anticipated flood elevation were clipped to root mat-level to determine if this treatment would improve root and soil persistence during the flood and hasten habitat recovery.

The Working Group was successful in meeting the revised measures, and the flood waters rose only to the estimated level, sparing vegetation in the error zone. However, as expected, over 95% of the primary habitat below the inundation line was lost. Plant species important to KAS showed essentially no ability to persist during floods, and clipping stems provided little protection from scour. The Working Group estimates that it will take several years for all KAS habitat to recover to preflood levels. The spring season following the flood was mild, and KAS had an extended breeding season with two reproductive peaks before fall. Therefore, KAS population was not considered to be at greater risk as a result of the experimental flood.

Features that contributed to this successful adaptive management experiment included:

1. Establishing the KAS Working Group two years before the experimental flood. As a result, the research team was experienced with the site, the species, and the research protocols. All agencies with an interest in the KAS population were represented, including the U.S. Fish and Wildlife Service.
2. The agencies associated with the KAS Working Group all agreed that the experimental flood was likely to benefit the Grand Canyon ecosystem. This common understanding and approval improved chances for conservative

compromise, and allowed Working Group members to share ideas without concerns about conflicting agency agendas.

3. Although only two populations of KAS were known to exist, the Vasey's Paradise population was relatively large for an endangered species (>10,000 individuals throughout the 1995 growing season). This allowed the Fish and Wildlife Service to allow loss of some individuals without abrogating their responsibilities under the Endangered Species Act.

While the experimental flooding was approved, the endangered species status of KAS still reduced experimental options under adaptive management. Flood levels that would have removed substantially more KAS habitat were not considered, and no area of vegetation at Vasey's Paradise was set aside as a control because the extreme likelihood of losing all snails in the inundated habitat was unacceptable.

Managing U.S. Waterfowl Harvests (Johnson and Williams 1999)

Long-standing deficiencies in waterfowl harvest management have lead the U.S. Fish and Wildlife Service to adopt an adaptive management approach since 1995 (Johnson and Williams 1999). These deficiencies include lacking well-defined objectives, failing to account for uncertain management outcomes, an overly subjective and complicated decision-making process, and inadequate feedback mechanisms.

The management approach framed harvest management in terms of sequential decision making under uncertainty as stochastic control processes. The manager periodically observes the system's state (population size and environmental features, etc.) and takes a management action (hunting regulations). Based on this action, the manager receives immediate benefits and incurs costs related to the management objectives. The resources' system subsequently evolves to a new state, with the change being influenced both by the management action and other uncontrolled factors. The manager then observes the new system state and makes a new decision. Management's goal is to make a sequence of such decisions, each informed by the system's present status, maximizing benefits and/or minimizing costs over an extended period of time. A prescription of optimal management actions for each system state at each time constitutes an optimal management policy (Johnson and Williams 1999).

Adaptive harvest management can be characterized as a Markov decision process. By limiting modeling population responses to management, limiting the number of management options, and accounting for stochastic effects and system uncertainties, it is possible to identify action-specific transition probabilities and returns needed to use the optimization algorithms available for Markov decision processes. The harvest model identifies four sources of uncertainty:

1. uncontrollable environmental variation (stochastic uncertainty);
2. partial controllability, expressing the lack of concordance between intended and actual management controls (administrative uncertainty);
3. structural uncertainty due to the fact that managers face incomplete understanding of biological and ecological processes (scientific uncertainty); and

4. uncertainty due to partial observability resulting from the fact that all management interest parameters can be known only within the precision afforded by extant monitoring programs (also scientific uncertainty).

Thus this process is *passively adaptive* in the sense that informative changes in model probabilities occur as an unplanned by-product of the regulatory process. This process explicitly accounts for structural uncertainty by using empirical assessments of model probabilities. The main disadvantage of a passively adaptive process is failing to recognize that harvest policy itself can be used as a tool to reduce structural uncertainty. The recognition that some regulatory strategies are more informative that others has led to considering more *actively adaptive* approaches (Johnson and Williams 1999), which involves a trade-off between short-term management performance and the long-term value of knowing which alternative model of system dynamics is most useful. The Markov decision process can accommodate optimal adaptive policy by expanding the modeled system to include an information state. Temporal transitions in the information state are a function of regulatory actions in the same way that temporal changes in the resource state are a function of actions.

Waterfowl biologists have often advocated experimenting with regulations to resolve questions of uncertainty about the effect of harvest on annual survivorship. However, little has been done—largely due to concerns about short-term risks to harvest opportunity that experimentation might entail (Johnson and Williams 1999)—despite the fact that the focus on adaptive harvest management is not on learning rates or short-term harvest, but on regulations that provide an optimal balance of short- and long-term harvest benefits. As Johnson and Williams contend,

The focus on adaptive harvest management is not on learning rates or short-term harvest, but on regulations that provide an optimal balance of short- and long-term harvest benefits.

> Although the ultimate fate of adaptive harvest management of North American waterfowl remains uncertain, we believe that ancillary benefits are increasingly apparent. The process has provided an effective link between data and decisions by integrating monitoring, assessment, and decision making in a coherent framework. The explicitness demanded by an adaptive approach has helped to focus attention on important biological and social issues and has guaranteed greater accountability in management decisions. A greater acceptance of management uncertainties, combined with more rigorous and focused assessments, has fostered a greater willingness among at least some managers to challenge dogma and traditional beliefs.
>
> The use of adaptive management for regulating waterfowl harvest in the United States is likely to continue, but its long-term viability is by no means assured. It is not yet clear that waterfowl managers will acknowledge the limits to performance imposed by uncertainty and act accordingly. Nor is it clear that managers are prepared to invest the same energy and resources in collecting information on resource users as they have on the resource itself, even if it means management objectives remain ill-defined and unmet. **Ultimately, the success**

> **of adaptive harvest management depends on a general agreement among stakeholders about how to value harvest benefits and how those benefits should be shared…. It is these unresolved value judgments, and the lack of effective institutional structures for organizing debate, that present the greatest threat to adaptive harvest management as a viable means for coping with management uncertainty**. (emphasis added) (Johnson and Williams 1999)

Stakeholders' general tendency to zero in on management initiatives' short-term affects necessitates that adaptive management strategies explicitly consider how stakeholders value the resource, and what knowledge they can contribute. Well-defined objectives can also improve the process.

Co-Managing Salmon Fisheries in British Columbia (Pinkerton 1999)

Two regional attempts at co-managing salmon fisheries by local stakeholders were examined in British Columbia, Canada (Pinkerton 1999). A key premise is that participants in locally based institutions that have a significant decision-making role have the potential to devise regulations that are more flexible, adaptable, and appropriate to specific situations than more generic regulations developed by centralized agencies.

The West Coast Vancouver Island (WCVI) region, like others, has a long history of salmon stock management policies that have resulted in gradually declining wild populations and local communities' increasing dependence on such stocks. This remote area suffers from licensing and catch allocation policies that reward fishermen and companies with the greatest access to capital and the ability to combine many smaller licenses into larger, more capital-intensive vessels with greater fishing ability. The WCVI has experienced transformed fundamental attitudes, communication patterns, and trust, which has led to a willingness to partner, learn, and work together (Pinkerton 1999). Aboriginal and nonaboriginal communities, including sport and commercial fishing interests, expressed regret about past enmities and made a commitment to work together to solve regional problems. They formed a steering committee composed of the major interest groups in the region, which developed the initial institutional framework in terms of its relationship to government, and the basic representational and accountability principles that guide it in forming the regional management body. It has been accepted by most federal and provincial governments as a group representative of the region.

An early project of the WCVI effort was an adaptive selective harvesting initiative in partnership with the West Coast Trollers Association and the Fisheries Centre at the University of British Columbia. The project would have paid for a timely and accurate catch monitoring effort out of the catch allocation. The trollers wanted to target more abundant Canadian sockeye salmon or chum salmon stocks while minimizing their by-catch of coho and Chinook salmon. The project would have enabled analyzing the best selective fishing strategies, and the information collected would have been relayed to the regional body and to the public and government about a week after collection. However, a desire by the federal fisheries management agency, the Department of Fisheries and Oceans (DFO), to maintain exclusive control of the data was a barrier to implementing

this community-based conservation initiative. Proposals to reduce by-catch through adaptive management experiments have been unsuccessful (Pinkerton 1999). Instead, DFO focused commercial fishing innovations on major gear alterations intended to decrease mortality of fish encountered, rather than on fishing strategy modifications that would reduce encounters with nontarget species. This DFO strategy had the unintended effect of locating the majority of acceptable innovations in commercial fishing in the large-vessel purse seine fleet. Most purse seiners are corporate vessels and sell into the lower-value, mass-produced canned salmon market. In contrast, the troller sector, dominant in WCVI, is small-scale, mostly operator-owned, and produces higher quality salmon for the fresh, frozen, and smoked markets.

The second region, Lower Fraser River, is dominated by small-scale gillnet fisherman. Because of the concentrated abundance of salmon funneling through the lower Fraser River, gillnetters had the capacity to survive in one area with efficient techniques and without major capital investments (Pinkerton 1999). Unlike WCVI, which suffered from regional inequalities, the Fraser River communities suffer from their lack of political organization and marketing connections. But their small-scale operations have the advantages of location, efficiency, flexibility, and adaptability. In this case, DFO's fishing time closures, and fear that all lower Fraser commercial fishermen could lose access to their traditional allocation of chum salmon, were the forces behind innovation and developing a partnership between aboriginal and nonaboriginal fishermen.

The partners believed that they had a better chance of regaining access to chum salmon by working together. In 1995, the partners obtained a DFO experimental license to conduct a selective live-capture beach seine fishery targeting abundant chum salmon stocks, and live-releasing the nontarget by-catch of depressed steelhead, coho, and Chinook salmon. This fishery innovatively contained an important element of stock assessment research on the nontarget species, which were tagged as they were live-released. The harvest's highly controlled nature made it very easy to monitor and to alter in response to information. Further, the license was experimental, connected to detailed reporting, and was sensitive to what was learned.

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In 1996, DFO considered the results successful and invited other applicants for this type of fishery to operate in other parts of the river. Five types of innovative partnerships between aboriginal and commercial fisherman either resulted or were proposed for the second and third year of the experimental license's operation using other selective technology, other species of salmon, and other methods to reduce stress on fish or encounters with nontarget species. However, the experimental fishery was opposed by most commercial and sports groups, who feared that this effort would gain privileged allocations for the participants. Some also resented the fishery for cooperating with aboriginal groups on the river, whose rights to a special allocation of commercial fish are being challenged both politically and legally. The local effort is also feared by the major

mass-production processors, who see that small-scale live-capture harvesting techniques could result in developing new, higher-value marketing channels (Pinkerton 1999).

These two regional efforts identified key barrier categories to community-based cooperative conservation initiatives (Pinkerton 1999):

1. distrust and resistance of management agencies, and
2. lack of broadly organized political support.

Barrier 1 was manifested in the government's desire to control data, which can be overcome by data-sharing through partnerships, credible third parties, and joint data banks. This barrier was also seen in the government's tendency to conduct single-species management for maximum biological or economic yield, versus managing for a broader array of stocks and ecosystem linkages. Agencies could overcome this barrier by engaging in the scope of activities appropriate to the problems being addressed.

Category 2 barriers were manifested in the policy's domination by major DFO clients. This will require broadening the base of support for innovation by building a larger, coastwide constituency (Pinkerton 1999). Further, privatization policies favored by many economists, and increasingly adopted by DFO, alter access and place it ultimately in the hands of private owners who do not necessarily have any commitment or attachment to a particular area or the salmon stocks using it. A key driver of privatization has been reduced funding and downsizing government agencies. In the search for greater efficiencies and cost reductions, agencies tend to favor cost recovery programs from the fleet, which are most rapidly achievable through privatization and concentration of access rights. Thus, it is the bureaucracy's preferences, rather than conservation or ecosystem concerns, that tend to drive privatization strategies toward higher levels of concentrated ownership (Pinkerton 1999).

Despite their success in terms of species conservation, a cooperative selective harvesting initiative resulted in local stakeholders' economic losses due to the government agencies' lack of willingness to share experimental data results. And an adaptively managed fishery experiment was sidelined by powerful stakeholders. Both attempts at adaptive management could have been successful with broadly organized political support for local efforts, and minimizing distrust of and resistance toward management agencies.

Managing Water Projects in New South Wales, Australia (Gilmour, Walkerden et al. 1999)

Gilmour, Walkerden, et al. (1999) review three adaptive management case studies in New South Wales, Australia, specifically looking at adaptive management's role in education, as a negotiation process, and in policy formulation and evaluation. The three case studies involved managing water use and quality in the urban fringe around three water systems: South Creek, Tuggerah Lakes, and the Sydney Water Catchment access. Each involved local government bodies responsible for management and policies, and the affected stakeholders.

In the South Creek case, participants explored urban development's environmental impacts, and alternative policies' effects in addressing those impacts, in a series of meetings conducted in 12 days during 1993-1994. A simulation model of the policy options, which related land use and water cycle management strategies, was defined in workshop sessions and in working groups. System status indicators displayed as graphs and maps, and policy options covered the three system's major dimensions: water management, land management, and socioeconomic issues.

The workshops' careful composition (a wide range of government agencies, land developers, and community organizations were invited to participate) led to a high level of consensus about the policy outcomes; the Regional manager, who had become the project's "institutional champion," supported the outcomes.

For new urban developments, the management focus identified was urban run-off and sewage effluent. The study concluded that pollution loads generated under existing land use patterns and under proposed future developments would not meet water quality guidelines, even given the high level of uncertainties. A major internal report was prepared outlining the project's outcomes, and the groundwork for adaptive management was put in place. The workshops' careful composition (a wide range of government agencies, land developers, and community organizations were invited to participate) led to a high level of consensus about the policy outcomes; the Regional manager, who had become the project's "institutional champion," supported the outcomes. Then a change in the Water Board's charter occurred that directed the Board away from resource management to corporate-style service provision, which resulted in abandoning the project.

The Tuggerah Lakes project involved 17 workshops and presentations to 7 community meetings. The workshops outlined the structure of a decision support model to assist in evaluating management strategies for the Lakes and their drainage catchment. Workshop participants included eight community representatives, two elected officials, six staff, an officer from each of three government agencies, and four invited technical specialists. Participants agreed that eutrophication was the main ecological risk confronting the Lakes, so the project's main focus was the sources, fate, and management of nutrients and sediment in the catchment and the Lakes. Participants identified a wide range of uncertainties, such as the ecological consequences of enlarging the existing entrance channel to the ocean, effectiveness of stormwater management structures, and influence of lake sediments on nutrient dynamics. Policy strategies were also identified to control nonpoint sources and to improve flushing the Lakes.

By the end of the workshop series, a general management strategy was clear, but an action plan had not been developed. Although the original "institutional champion" was transferred, a member of the workshop consulting team was appointed to this position so internal support for the project continued, and an implementation program was developed and enacted. A strong feature of the process was participation by both elected officials and their staff, and community representatives. Despite this cooperation, the transfer of knowledge gained in the project was low, and there was a lack of commitment within the

organization. Further, there was a lack of support for the outcomes by government agencies that were not fully committed participants.

In the third case, six workshops were held regarding Sydney Water Catchment access to evaluate issues, explore management options, and make recommendations. Thirty stakeholders, managers, and scientists were selected by sponsoring organizations, in discussion with workshop consultants, based on their knowledge of the geographic area, experience and awareness of current and prospective activities, and expertise in technical disciplines. The project was in reaction to intense lobbying by some stakeholder groups, especially those seeking increased access, and brought together many groups with long histories of mutual antagonism. Therefore, workshops were structured to gradually move from general to specific issues; participants were encouraged to distance themselves from the detail of their stakeholder positions to arrive at a consensus on underlying technical and social issues presented in the workshops. A series of technical meetings was held during the workshop process to provide opportunity for discussing technical issues.

The participants found that indicators for tracking the impacts of recreational activies on the catchments were lacking. Two approaches were identified for making progress in the debate:

1. collecting and interpreting additional information to reduce the uncertainty of activity-impact relationships; and
2. community consultation on the risks, costs, and benefits of recreational access decisions (Gilmour, Walkerden et al. 1999).

The workshop recommended studies and strategies supporting these approaches. Further, until these studies produce credible information indicating that it is safe and socially acceptable to do otherwise, participants feel the current regulations for the protected areas around the reservoirs should be retained. The Sydney Water Corporation had not yet considered the practicality of implementing these recommendations, which included an adaptive management strategy, at the time of the study (Gilmour, Walkerden et al. 1999).

All three cases' adaptive management strategies showed great promise, but were hampered by powerful governmental stakeholders, the political process, and lack of community support.

The Northwest Forest Plan (Stankey and Shindler 1997; Stankey, Bormann et al. 2003; Thomas 2003a)

The Record of Decision (ROD) for the Northwest Forest Plan (U.S. Department of Agriculture 1994) provided guidance for managing USDA Forest Service and USDI Bureau of Land Management lands within the range of the northern spotted owl. The selected management alternative was grounded on the principles of conservation biology, emphasizing risk avoidance to the region's federal lands in the short term through applying the Precautionary Principle. The plan established a system of terrestrial and riparian reserves that, when combined with other protected areas (national parks, wilderness, etc.) covered almost 80% of the planning area. In addition, a set of very

comprehensive and prescriptive standards and guidelines further restricted management activities and development, even on areas outside of the reserves.

Following the advice of the Forest Ecosystem Management Assessment Team (FEMAT), created by President Clinton to address concerns about declining old-growth forests and their associated wildlife, the plan emphasized an adaptive management approach by allocating 10 Adaptive Management Areas (AMA) covering about 1.5 million acres, or 6% of the planning area. These areas were established "to encourage the development and testing of technical and social approaches to achieving desired ecological, economic, and other social objectives" and to help agencies "learn how to manage on an ecosystem basis in terms of both technical and social challenges" (U.S. Department of Agriculture 1994). Adaptive management was thought to complement the precautionary short-term strategy by offering a long-term strategy that would expand knowledge of the complex biophysical system and its interaction with the social and economic systems. This, in turn, would lead to improved management policies.

Stankey et al. (2003) evaluated implementing the adaptive management portion of the Northwest Forest Plan in 1998. They identified a number of barriers to successfully using the flexibility provided by the AMAs.

1. *Leadership and definitional barriers:* AMA coordinators and line officers were confused as to where responsibility lay for developing policy direction for adaptive management and the AMAs. Early on, the Forest Service Regional Office decided not to provide direction, guidance, or other instructions for implementing adaptive management, intending to avoid imposing top-down rules. This silence was interpreted as a lack of interest. Further, those charged with implementing adaptive management had differing conceptions and expectations regarding its definition, purpose and objectives.
2. *Institutional barriers:* AMA coordinators and line officers were given few incentives to undertake adaptive approaches, and argued that experimenting and risk-taking are not standards against which they are evaluated. They saw their agencies as risk-adverse because a climate existed where the burden of proof had shifted to land managers to provide rigorous evidence that any proposed action would not lead to adverse consequences for threatened and endangered species. This is clearly an anathema to the concept of adaptive management. Further, as budgets declined, funds were diverted away from the AMA's to fund implementing the Northwest Forest Plan's operational aspects. The tendency for agencies to operate according to prescriptive approaches and standardized rules also constrained innovation, even when specific direction providing license to deviate within the AMAs was provided.

The tendency for agencies to operate according to prescriptive approaches and standardized rules constrained innovation, even when specific direction providing license to deviate was provided.

3. *Statutory and regulatory barriers:* Laws such as the Endangered Species Act, and the regulatory agencies that enforce such laws, provided little latitude to practice adaptive management. Under prevailing interpretations, actions judged to pose a risk to listed species are opposed, even when the efficacy of precautionary

approaches is poorly understood (Gunderson 1999). Guaranteeing no adverse consequences establishes a difficult, if not impossible, decision criterion to satisfy.

4. *Barriers to learning:* Despite the clear concept of learning by doing inherent in adaptive management, there was no systematic design and documentation to promote learning or to address the question of what it means to learn.

Guaranteeing no adverse consequences establishes a difficult, if not impossible, decision criterion to satisfy.

The AMA coordinators and line officers concluded that in such a risk-adverse, litigious environment, an experimental-based type of adaptive management would be difficult to implement. Gunderson (1999) found that when minimizing the possibility of failure dominates the policy and management process, uncertainty is traded for a "spurious certitude" that provides a comforting but illusionary sense of predictability and control.

At the request of the Regional Forester of the USDA Forest Service Pacific Southwest Region, Dr. Jack Ward Thomas—who led the original Forest Ecosystem Management Team (FEMAT) team that developed the Northwest Forest Plan—was asked to review progress in implementing the adaptive management plan in the two California Adaptive Management Areas designed by the Northwest Forest Plan. Thomas (2003b) concluded that the AMA's were not being managed any differently than lands not so designed. Initial efforts on the Goosenest AMA on the Klamath National Forest were deemed successful from a public point of view; however, the AMA coordinator's position was terminated due to budget problems and, perhaps due to reduced public involvement, or the fact that nearly all of the timber harvested on the Klamath National Forest comes from the AMA, project appeals on the AMA are becoming more commonplace. "Testing of S&Gs (standards and guidelines provided in the original Record of Decision prescribing how projects will be conducted) has become less acceptable due to both 'internal and external resistance' and reliance on 'subjective assessment' is less accepted" (Thomas 2003b).

Lee (2001), in an appraisal of adaptive management, states that the Forest Service uses the following definition of adaptive management in implementing the Northwest Forest Plan: "'for land managers, researchers and communities [to] work together to explore new methods of doing business'" (Olympic National Forest 1998 as quoted in Lee 2001). Lee (2001, p. 12) concludes that "The Forest Service definition of adaptive management does not emphasize experimentation but rather rational planning coupled with trial and error learning. Here 'adaptive' management has become a buzzword, a fashionable label that means less than it seems to promise."

On such a large scale, despite the Forest Service's best efforts to involve stakeholders at multiple levels of decision making, this adaptive management project suffers from unrelated changes of key stakeholders, and stakeholder-imposed political and legal gridlocks that could be removed through integrating public participation and values into the early modeling stages.

LESSONS LEARNED

In the case of developing air quality standards in the United Kingdom (Stubbs and Lemon 2001), different and often conflicting interpretations of the science were overcome through identifying the key group network and a facilitated stakeholder dialogue in which the facilitator created and maintained conditions that encouraged exposing assumptions and postponing judgments that invoke defensive behavior. This stage of the process deliberately revealed diverse perceptions of the same issue in order to reach some level of consensus about the issue's complex nature. The process continued using techniques that facilitate more radically exploring possibilities for collective action through creative thinking. The outcome of the overall process is an adaptive response network, a virtual organization of stakeholder representatives with an enhanced capacity for joined-up and creative thinking.

The Columbia River Basin adaptive management effort was initially successful as a result of strong leadership on the Northwest Power Planning Council, and available funding for experimentation through an annual rate-payer assessment on power usage (Lee 1989; McLain and Lee 1996). However, in the end, failure to reach agreement on the nature of the issue among the various stakeholders, and litigation that led to listing specific genetic strains of anadromous fish, resulted in limited accomplishment.

The Florida Everglades case illustrates the problems of implementing adaptive management when there is little or no resilience in the ecological system, lack of flexibility in the management agencies, and stakeholders who are able to stalemate any implementation of alternative strategies ("…lack of flexibility in the extant power relationships among stakeholders" (Gunderson 1999)). The experience to date has been one of a successful assessment by technical specialists, followed by little or no active experimentation. The uncertainties of the chronic resource issues that led to the assessment seem to have been replaced by the certainty of a cumbersome planning process, and formalizing interactions among management agencies and stakeholders (Gunderson 1999). Gunderson believes that understanding and diagnosing ecological resilience and institutional flexibility are important roles that adaptive management can perform. Further, if that resilience cannot be defined during the assessment phase, then it might be discovered through a series of "imaginative, smaller scale experiments, given the institutional space to conduct such explorations" (Gunderson 1999). He concludes that, in spite of obstacles, adaptive management is an important approach to ecosystem management that seeks certitude in both science and social processes. Further, adaptive management is effective in resolving multiple competing hypotheses around resource issues. It can change the ways in which management agencies assess resource issues, it can nurture and test new theories, and it can establish new ways of communicating among the various interests.

In his examination of adaptive management in riparian and coastal ecosystems, Walters (1997b) sees adaptive management as a science-driven process requiring developing dynamic models that attempt to make predictions about alternative policies' impacts. A necessary second step is to test these models. However, few efforts in adaptive

management planning have proceeded beyond the initial step of model development. He describes four reasons for low success rates:

1. modeling for adaptive management planning has often been supplanted by ongoing modeling efforts, possibly based on the assumption that detailed modeling can somehow substitute for field experimentation;
2. adaptive management experiments have often been seen as expensive and/or risky, compared to best management practice baseline options;
3. there may be strong opposition to experimental approaches by those protecting various self-interests; and
4. deep value conflicts within the various scientific and stakeholder communities prevent policy change.

In a response to Walter's article, Rogers (1998) argues that the problem is divergent operational philosophies and reward systems between scientists and managers. While scientists seek problems of intellectual difficulty rather than immediate usefulness, managers are driven by their institution's pragmatic needs. Each group needs to adopt these approaches among their peers, but must find common process and purpose when working together. He further identifies three problem areas:

1. ecology is not serving management well, and adaptive management is not being accepted and applied in practice, perhaps because the approach tries to make scientists into managers and managers into scientists;
2. inaction is a most comfortable option for managers; and
3. monitoring becomes too expensive for management to implement.

The major lesson from the Fort Huachuca example (Gen 2001) is that excellent stakeholder involvement can be trumped by decisions made at higher levels in the organization, in this case decisions made by the Base Realignment and Closure Commission. Thus, while local stakeholders were calling for reduced water use, Fort Huachuca was obligated to implement base expansions decided by national policy makers. This led to the conclusion by some stakeholders that the Fort's public involvement efforts are moot and that litigation is the only effective way of influence. Gen concluded that the organization's bureaucratic structure must be integrated into the participatory process, and that there must be agreement with the stakeholders on the decision-making process, that is, "deciding how decisions will be make."

In the case using watershed councils in southwestern Oregon (Habron 2003), without significant use and participation, adaptive management in watersheds dominated by private lands holds little promise. "It is crucial that the private property rights concerns of landowners fit within the institutional constraints and opportunities regarding watershed councils" (Habron 2003).

The Glen Canyon Dam case successfully applied adaptive management involving a listed species, the Kanab ambersnail (KAS) (Meretsky, Wegner et al. 2000). A combination of close working relations between the various agencies, agreement among all agencies on the need to reintroduce flooding into the Grand Canyon ecosystem, and the fortuitous

circumstance of higher-than-expected populations of KAS resulted in quick, on-the-ground modification of the study protocols and a successful experimental flooding.

The study of three water cycle management projects in New South Wales, Australia, also identified several important considerations (Gilmour, Walkerden et al. 1999):

1. Selection of participants in key workshops requires more attention if the goal of community ownership of the adaptive management strategy is to be achieved. A more public selection process with a series of community meetings could proceed the workshops in an effort to build community support.
2. Concerns about the political process, raised as potential problems early in each of the projects, reflected a cynicism about what influence studies such as those undertaken by the consultants would have on decision making. There were fears that overenthusiastic use of the modeling tools might occur. Later, concerns were raised about the model in relation to uncertainty of the data, identifying key data, and the sensitivity of the process relationships.
3. To address various concerns, the workshop consultants stressed to the participants:
    a. they were seeking ways to manage amidst uncertainty, and uncertainty itself is unavoidable;
    b. some simplification is involved in all efforts to understand ecosystems: the goal is to use simplified models to assist decision making, not to substitute models for judgement; and
    c. all policy development processes run the risk of being derailed by external factors; the goal in the workshops is to provide better resources for policy implementation, acknowledging the risks.

In a review of six large-scale adaptive management studies, Gunderson (Gunderson, Holling et al. 1995)found that "Mission-oriented research, whose goal is to validate existing theory… generally hinders the development of alternative views and leads the system to brittleness." The scientific method is designed to disprove hypotheses, not necessarily proving what will work. Gunderson, Holling et al. (1995) believe that involving and educating the stakeholders who are part of the system are essential to building resilient solutions and removing gridlock.

In a literature review, Johnson (1999a) suggests three main problems in making adaptive management work: integrating stakeholders more effectively into decision making, developing institutions that are amenable to adaptive management, and embracing risk as a part of management. Management is aimed at increasing the value of a resource to humans, and any management, therefore, should consider how stakeholders value the resource and what

Management is aimed at increasing the value of a resource to humans, and any management, therefore, should consider how stakeholders value the resource and what knowledge they can contribute.

knowledge they can contribute. A lack of well-defined objectives that reflect stakeholder values seems to result in less support for the process. "Future applications of adaptive management might be improved by including more open discussion of differences in stakeholder values with the goal of developing some objectives, perhaps very broad, that most stakeholders can agree to" (Johnson 1999a).

While adaptive management considers change and cooperation as inherent to management, most management agencies tend to resist change and wish to control the management process as much as possible. Johnson (1999a) suggests a new management paradigm that sees management agencies as facilitators and partners with citizens rather than as solution providers. He further suggests that adaptive management should be applied not just to the resource, but to the agencies themselves. Such experiments would explore the relationships between and among agencies and stakeholders to find new ways to promote flexibility, cooperative management, and a long-term view (Johnson 1999a).

> As with uncertainty, the risk of economic loss or of negative effects on the resource is inherent in all resource management, whether new and innovative or status quo, and can never be eliminated. However, managing to maximize benefits may actually increase some types of risk. An alternative is to promote resilience of the natural system and of the management system, such that we maintain acceptable, but perhaps not maximal, levels of resource use while avoiding unacceptable negative effects and catastrophes. Adaptive management can help by determining the level of risk involved under different actions and incorporating that knowledge into policy choice. However, defining "acceptable use" and "catastrophe" is more a social than a scientific question (Johnson 1999a).

From 10 years of research and efforts to implement local co-management in British Columbia salmon fisheries, we learn that good models and political will exist in communities to design and test local and regional institutions for successful involvement in management (Pinkerton 1999). However, there are significant barriers to making it happen. Chief among these are distrusting and resisting management agencies, and lacking broadly organized political support for such local efforts.

RECOMMENDATIONS AND CONCLUSIONS

The concept of adaptive management has matured since its initial application to natural resources as adaptive ecological management and assessment by Holling (1978)—as a science-driven process with some stakeholder involvement, to the current adaptive collaborative management of Buck (Buck, Geisler et al. 2001)—as a stakeholder–driven, facilitated process with scientist involvement to achieve stakeholder networks that learn and adapt together. Shindler and Cheek (1999) provide an important discussion of the lessons from involving citizens in adaptive management, largely based on national forest planning experiences. They conclude that

> citizen-agency interactions are more effective when (1) they are open and inclusive, (2) they build on skilled leadership and interactive forums, (3) they include innovative and flexible methods, (4) involvement is early and continuous,

(5) efforts result in action, and (6) they seek to build trust among participants. Particular attention to the situational context of actions and decisions helps to determine the relevance of adaptive management for individuals in these settings. (Shindler and Cheek 1999)

There is a growing recognition of the importance of the social sciences to develop a theory explaining why cooperation in collective actions is highly variable. And, institutional stability and organizational culture in the management agencies that enables experimentation and learning does not exist (National Research Council 1996). Further, it is difficult for resource professionals to put a long-term plan for public engagement into action when the public climate is hostile and calls for immediate results (Shindler and Cheek 1999).

Adaptive management is necessary but not sufficient for coping with wicked problems.

From reviewing the literature, it is clear that while adaptive management can address issues of scientific uncertainty, it does not result in agreement on policy choices when the stakeholders cannot agree on predicted outcomes; adaptive management is not a process for coping with disagreement over management goals and objectives (Johnson and Williams 1999). Other obstacles to effectively using adaptive management include stakeholders failing to agree on the nature of the issue, the lack of flexibility in the power relationships among stakeholders, or the lack of resilience in the ecosystem (Gunderson, Holling et al. 1995; Gunderson 1999). **Thus, it seems that adaptive management is necessary but not sufficient for coping with wicked problems.** It helps resolve issues of scientific uncertainty, but does not aid in resolving differing values among the various stakeholders. Often, these differences in values will prevent agreement on issues and acceptable solutions to allow managers to move forward in an adaptive mode.

While few examples of completely successful adaptive management experiences are available, a number of important concepts and recommendations have emerged from examining case studies.

1. Whenever possible, all stakeholders, interested federal, state and local agencies, and decision makers in the responsible organization's chain of command should be involved.
2. There must be agency commitment to the stakeholder engagement and adaptive management processes, including funding for both monitoring and experimentation.
3. There must be an agency cultural shift and stakeholder tolerance for reasonable risk taking.
4. While the precautionary principle is likely to guide short-term decision making in cases of high uncertainty, provision must be made to allow for experimenting.
5. The entire decision-making process must be open and transparent.
6. The presence of endangered species requires actively engaged responsible regulatory agencies, such as the U.S. Fish and Wildlife Service.
7. Using small experiments selected to respond to stakeholder risk and uncertainty preferences should be explored. Such experiments help build learning networks, build trust, provide short-term results critical to maintaining stakeholder interest,

solve problems important to the stakeholders, provide lower risk to ecological communities and endangered species, and are easier and less costly to implement.

8. The process must be iterative, incorporating and responding to stakeholder values.

As Bormann et al. (1994, p. 8) note,

> Because societal values and ecological capacity must be integrated to achieve sustainability, iterative interaction is required. Defining what is ecologically possible is not efficiently pursued without first knowing what people want; reconciling what is desired with what can be sustained and finding creative solutions require understanding what is and is not thought to be possible. Thinking about new possibilities does not come easily, and ideas from a broad cross-section of society are needed.

To increase effectiveness of adaptive management workshop processes, Gilmour et al. (1999) recommend:

1. exploring the difficulties and uncertainties of ecosystem management, while at the same time exciting participants with the potential for inventing new ways of managing;
2. emphasizing the role of workshops as forums for negotiation from the start, with the intention of signing off on a management strategy if a consensus emerges; and
3. making a self-conscious commitment to community development as an aspect of projects, with a view to developing skills in holding key stakeholders accountable in an assertive way.

A crucial point, however, in terms of adaptive management at the ecosystem level, is that complex, large-scale decision making not only imposes enormous financial burdens (ultimately upon taxpayers), but it simply takes too long. In the Sierra Nevada Forest Plan Amendment case, 12 years have passed since the start, and the wicked problem is still generating challenges from multiple stakeholders. A management decision could be designed to be revisited every five years as a matter of policy, but at the ecosystem scale the environmental impacts are so large that a full-blown Environmental Impact Statement (EIS) will be required. The current timeline for an EIS is two or more years, so the planning process would be continual.

Local experimentation and monitoring, on the other hand, could feed back into such a recursive planning process, perhaps allowing for smaller-scale plan revisions as needed. Projects and experiments are best at a small scale, involving local stakeholders ("citizen–agency interaction," as Shindler and Cheek (1999) call it), the monitoring and evaluation also at the local level. Such small-scale projects could be extrapolated for landscape-level management decisions at lower cost than large-scale experiments.

Clearly, adaptive management can be a successful component of national forest ecosystem management, but it is not enough. Carefully designed public participation and accountability are equally essential.

CHAPTER 7. RETHINKING PUBLIC PARTICIPATION IN ADDRESSING WICKED PROBLEMS

INTRODUCTION

For much of the last 30 years, descriptions of how public policy advice should be constructed have been dominated by a paradigm that relied heavily on experts and a well-defined "rational" process. Standard textbooks in the field describe a cyclical, multi-step process that includes:

- Define the problem
- Establish decision criteria
- Generate potential alternative policies to address the problem
- Evaluate the alternatives using the criteria
- Recommend a course of action
- Implement the decision
- Monitor performance

The cycle results both from lack of total success in resolving the problem and the recognition that policies often generate unforeseen problematic effects that in turn require analysis to resolve. Different texts emphasize different stages of this process, but there has been general agreement on its efficacy (Dunn 1994; Bardach 1996; McRae Jr. and Whittington 1997). And the same basic approach has been advocated for individual decision making as well (Hammond, Keeney et al. 2002).

Over much of the same period, there has been increasing recognition that in at least some settings this methodical approach to decision making breaks down. Indeed, it is often characterized as contrasting sharply with democratic principles and processes (see Walters, Aydelotte et al. (2000) for a more complete discussion of this point). Of particular note for our purposes, there is now fairly broad agreement that this traditional approach breaks down when applied to wicked problems—such as managing the Sierra Nevada National Forests.

As noted in Chapter 3, the Sierra Nevada management problem qualifies as a wicked problem. The term was first applied to forest management by Allen and Gould (1986). More recently, Shindler and Cramer (1999), Shindler (2000) and Wang (2002) have all applied the term to managing public forests. In brief, the disparity between traditional approaches to policy analysis and the challenges inherent in wicked problems is apparent when we review several key aspects of wicked problems (see chapter 3 for a more complete discussion of wicked problems):

- *There is no definitive formulation of the problem.* Finding the problem is the same thing as finding the solution; the problem cannot be defined until the solution has been found.
- *Wicked problems have no stopping rule.* Work on the problem stops not because of any inherent logic in the problem, but because money, time or patience run out.

- *Solutions to wicked problems are not correct or incorrect, but better or worse.*
- *There is no immediate, and no ultimate, test of a solution to a wicked problem.* Full consequences cannot be appraised until waves of repercussions have completely run out, and there is no way to trace all the waves through all the affected lives ahead of time or within a limited time span.
- *Every solution to a wicked problem is a "one-shot operation"*; because there is no opportunity to learn by trial and error, every attempted solution counts significantly. Actions are effectively irreversible, and the consequences' half-lives are long: every trial counts.
- *Wicked problems do not have an enumerable set of potential solutions*, nor is there a well-described set of permissible operations that may be incorporated into the solution.
- *Every wicked problem is essentially unique.*
- *Every wicked problem can be considered a symptom of another wicked problem.*

Among many analysts there is growing consensus that addressing wicked problems requires a greater level of public participation than has been the case in traditional analytic approaches (Rittel and Webber 1973; Fischer 1993; Haight and Ginger 2000; Steelman 2001). Not surprisingly, many advocate expanded participation in environmental management generally (Fiorino 2000) and forest management in particular (Shindler, Cheek et al. 1999; Shindler and Cheek 1999). Increasing calls for expanded public participation have been attributed to many factors, including a growing distrust of public institutions and officials (Fischer 1993; Thomas 1995); increased legislative requirements for public participation (Thomas 1995; Haight and Ginger 2000); the complexity and uncertainty of contemporary problems (Fischer 1993); different perceptions of risk (Slovic 2000); and a common recognition that decisions are never purely scientific—that politics and social values are inherent in all administrative decisions (Wondolleck 1988; Durning 1993; Fischer 1993; DeLeon 1995)
However, public participation has received mixed reviews from practitioners and evaluators. On the positive side, it has been credited with the ability to facilitate:

- trust, legitimacy, and mutual learning by incorporating public values into decisions (Pateman 1970; Fischer 1993; Beierle and Cayford 2002);
- conflict resolution among divergent interests (Gericke, Sullivan et al. 1992; Beierle and Cayford 2002);
- better substantive decision quality based on broadly evaluating interests, debate, and innovation (Gray 1989; Sample 1993; DeLeon 1995);
- increased decision commitment and acceptance: "People tend to support what they have a role in building"(Pateman 1970; Gray 1989; Sample 1993, p. 24);
- positive cumulative partnerships to enhance future policy endeavors and create goodwill (Gray 1989; Gericke, Sullivan et al. 1992; Beierle 2002); and
- stronger democracy built on a genuine attempt at inclusiveness (DeLeon 1995).

Conversely, it has been argued that broad participation is associated with:

- intensive resource commitments (e.g., money, time, and human capital),
- prolonged decision making (Sample 1993),

- decreased stakeholder trust,
- reduced decision quality,
- increased controversy and conflict, and
- diminished likelihood of successful outcome(s). (Steelman 2001)

In the sections that follow, we review public participation literature, noting the nearly universal call for greater participation in addressing societies' most difficult problems, including environmental and forest management. We summarize eight characteristics argued in the literature to be important for successful participation (this summary is expanded in the appendix). We review the substantial participation efforts undertaken by the Forest Service in the Sierra Nevada Forest Plan Amendment process, and argue that with wicked problems on the scale of the Sierra Nevada, public participation efforts face rather severe limitations. Finally, we offer suggestions to more productively incorporate participation in future planning efforts, including our "learning network" process model.

PARTICIPATORY DECISION PROCESSES

Public participation lies along a continuum of democratic practice. At one extreme, there is *pure representative democracy*, in which the electorate selects public officials who, in principle, need report to and consult with the public only at election time. Rare and short-lived are the politicians who follow such a course. At the other extreme lies *pure democracy*, in which all public decisions are made by the entire electorate's vote. Only rarely has this extreme proven workable for states or nation-states. Consequently, in actual practice the level and nature of public participation fall somewhere along this continuum. It is important to note that (1) the amount of participation acceptable in a given context is not static, and (2) over the past decade the level of participation expected by the public has substantially increased.

Participation is as used here a broad-based term describing various communicative processes intended to include the public in analyzing, planning, selecting, and potentially implementing government actions. Some authors distinguish public participation from stakeholder collaboration, with "public participation" denoting democratically involving average citizens in public decision making, while "stakeholder collaboration" signifies involving special interest groups or other populist representatives (Beierle and Cayford 2002). However, this distinction merely identifies different but closely related points along the participation continuum, and consequently we do not differentiate participation and collaboration.

Our approach is similar to Arstein's (1969) ladder of citizen participation, where the rungs represent the different levels of power citizens have in determining a policy outcome. Arstein asserts that "citizen participation" is merely another term for "citizen control," as the extent of influence ranges from no authority through full decision-making authority.

> For wicked problems, public agencies have more often than not tended to land on "rungs" of the citizen participation ladder that settle for "informing," "consulting" or "placating"—when outsiders argue that Arstein's "partnership" rung has a greater probability of ultimate success.

Arstein (1969) provides a useful tool to conceptualize participation; however, one should not conclude from her ladder that public agencies should consistently strive for "top rung" participatory processes—processes that grant citizens full decision control. Rather, it is important to achieve balance in participatory objectives and methods. The public does not always seek complete control over every public decision. However, for wicked problems, public agencies have more often than not tended to land on "rungs" that settle for "informing," "consulting" or "placating"—when outsiders argue that Arstein's "partnership" rung has a greater probability of ultimate success.

Lawrence and Daniels (1996)group the goals articulated for public participation as consisting of

1. efforts seeking to arrive at decisions that better achieve resource management objectives, and
2. efforts seeking to increase public support for decisions taken.

In the context of wicked problems, we will argue throughout this chapter that the first goal is either unattainable or unknowable due to the nature of the problems. Consequently, **public participation aimed at addressing wicked problems must focus on increasing public support for the decisions made**. This is not to say that all alternatives are equally viable from a scientific perspective. Rather, we argue simply that after applying the best available science, multiple alternatives will still remain with uncertain future outcomes, so the choice between these alternatives must be made based on non-scientific criteria guided by broadly held public values.

Stakeholders are individuals, groups, and organizations—including public agencies and government representatives—who have an interest in an issue or problem (Gray 1989; Selin and Chavez 1995). While some agencies distinguish stakeholders as individuals and groups external to the agency, our usage includes both internal and external interested parties as stakeholders. Further, stakeholders can define the issue, or the issue can define the stakeholders (Stubbs and Lemon 2001). One of the major challenges of participatory efforts can be the need to identify groups of stakeholders and bring these "clusters of shared interests and concerns" together in a learning-conducive environment (Gray 1989; Stubbs and Lemon 2001). Only then, it is argued, can stakeholders transcend their usual boundaries and belief systems to gain greater awareness of other stakeholders' perspectives and sensitivities, and to construct a mutually acceptable understanding of the wicked problem at hand.

One of the most prominent factors contributing to growing participatory decision making has been the realization that many policy decisions are not merely scientific and technical in nature, but also political and social, thus requiring investigating interests and values not easily reflected or incorporated in traditional analytic techniques. This observation is particularly true in wicked problems' inherently complex

Many policy decisions are not merely scientific and technical in nature, but also political and social, thus requiring investigating interests and values not easily reflected or incorporated in traditional analytic techniques (Beierle and Cayford 2002). This observation is particularly true in wicked problems' inherently complex context.

context. **Thus, a common thread across many policy issues today is the growing conviction that public participation is a critical component in achieving any sort of progress with wicked policy problems** (Selin, Schuett et al. 2000).

Shannon (1992) asserts the best way to address an intractable/wicked problem is to construct informed public knowledge by providing an opportunity for mutually exchanging information and deliberating to arrive at the most acceptable solution. Fischer (1993) contends that "contrary to technocratic expectations," the right approach to dealing with wicked problems, is "more—rather than less—citizen participation." In fact, he argues, "problem-solving [sic] in the case of wicked problems may literally depend on such collaborative methodological innovation" (Fischer 1993, p. 182). Dryzek (2000, p. 173) also supports this argument, asserting "Discursive democracy may be the most effective political means currently available to solve complex social problems, because it provides a means for coherent integration of the variety of different perspectives that are the hallmark of complexity." In the context of environmental management, Fiorino (2000) argues, "Indeed, the themes of cooperation, participation, integration, ecosystems, and regional/local problem solving define a vision for a new era of environmental management, a vision that is emerging almost case by case across the country."

Contributing to the shift from traditional analysis to participatory decision-making, and closely related to growing wicked policy issues, is the increasing awareness of the disparity in how people perceive risk. As noted in Chapter 2, significantly different risk perceptions are especially important aspects to acknowledge since they are often at the root of issue disputes and controversy (Gray 1989; Slovic 2000). For example, government agencies frequently adopt a technical view of a given issue, which often leads to a different understanding of possible risks than the public's social or economic sensitivities (Gray 1989). This different understanding frequently generates controversy over scientific reports' and expert opinions' accuracy, especially when "dueling scientists" disagree about conclusions drawn from the same information—and even about how much and what type of information is necessary to reach a sound decision. After 25 years of researching risk perceptions, Slovic (2000) concludes that a low level of technical understanding coupled with a high level of uncertainty and risk precipitates an increased public perception that there is potential for mistakes with devastating consequences. Given these findings, it may not be surprising that the public is significantly more likely to trust a university scientist's assertion than a government official's (Johnson and Scicchitano 2000).

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Gray (1989, p. 253) contends, "In order to reach agreement on the acceptability of technical input, the parties will need to agree on the underlying value premise." This can only be accomplished through a discursive process of mutual learning that allows all stakeholders to gain a better understanding of both their own position and others'. Findings such as these led the Committee on Risk Characterization of the National

Research Council to strongly advocate a decision process for situations involving risk that tightly integrates both technical analysis and broadly based public participation (Stern and Fineberg 1996).

Increased public participation is not the answer to every policy decision. In some cases, the public expects the administrative agency to make the decision without any input, accepting their legal authority or expertise (Sample 1993). However, many policy issues today fit the description of an ill-defined or wicked problem. For such problems, there is a substantial consensus across a number of disciplines that broadly based participation from all stakeholders in the decision-making process is essential (Fischer 1993). But the problem or issue's nature is not the only factor that may result in a call for expanded participation. Table 5 summarizes lists provided by Gray (1989) and Selin and Chavez (1995). In the table, factors are grouped into four broader classifications relating to problem characteristics, stakeholder characteristics, the history of the decision, and the particular decision context. The more characteristics from Table 5 present in a given decision situation, the greater the apparent need for carefully designed and rich public participation.

Table 5. Factors Suggesting the Need for Expanded Public Participation in Wicked Problem Decision Making

Problem/Issue Characteristics	• Both the problem's definition and solution are illusory (i.e., wicked problems) • The problem/issue involves uncertainty and risk
Stakeholder Characteristics	• Various stakeholders have an interest in a problem and cannot achieve a unilateral solution • Stakeholders are not easily identifiable in advance, or well-organized • There is possible disparity in stakeholder power and available resources • Stakeholders have various levels of expertise and knowledge • Stakeholders have different values and interests which have led to adversarial positions on other occasions • A common goal exists between different stakeholders that requires a collaborative effort to fulfill • A network exists, such as a chamber of commerce or community organization, where stakeholders have already forged alliances
History of the Decision	• Incremental or unilateral problem resolutions have not proven successful • Existing methodologies to address the issue have not been successful, and may even have compounded the problem
Decision Context	• A crisis exists where policy action has been paralyzed by adversarial positioning, by legal delay tactics, or where there is immediate danger, such as the need to protect endangered species or ecosystems • A third party is intervening who convenes the stakeholders as a neutral mediator • There is a legal mandate handed down by the legislature or the courts, such as with the National Forest Management Act • A charismatic leader's enthusiasm and vision persuades others to join in the participatory effort • Incentives for participation exist, such as matching funds for stakeholders to participate

Note. Compiled by the authors from Gray (1989) and Selin and Chavez (1995).

DESIGNING FOR SUCCESS

Thus far we have argued that effective public participation is essential in addressing wicked problems such as those presented in managing complex ecosystems in a highly charged political environment. In this section, we turn to a set of design considerations important in successful participatory efforts. In many instances, these considerations can be thought of as a continuum as well. For example, trust is often cited as one essential element in collective decision making, as it is necessary to foster cooperation and reduce individual opportunism (DeLeon 1995). Conversely, lack of trust can hinder a successful outcome (Fischer 1993; Shindler, Brunson et al. 2002). Thus it seems clear that the higher the level of trust between agency and participants, the greater the likelihood of success.

Based on our literature review, we have identified eight design considerations that should be addressed in formulating a strategy for public participation leading to successful policy efforts. The considerations are listed briefly here and described more fully in the appendix.

1. *The agency must commit to public participation*. This commitment has at least two dimensions. First, an obvious investment of both the necessary time and resources to engage in a participatory process. Beyond this investment, success requires the agency's willingness to accept different public values and concerns as legitimate.
2. *Identify and engage appropriate stakeholders.* Defining stakeholders can be an extremely complex process, but is necessary and can have serious consequences for the participatory effort's success. Research indicates that efforts that leave out stakeholders are less effective and less likely to succeed in implementation (Gray 1989).
3. *Clearly state objectives for participation.* Public managers need to convey their reasons for the participation effort, accurately define their own role(s) and the participants', and then follow through on their commitments (Shindler and Neburka 1997). Stakeholders frequently report that they are more likely to trust public officials who candidly state their rationale for being included in decision making and then follow through with their commitments (Shindler, Brunson et al. 2002).
4. *Assess the knowledge necessary for effective participation.* This knowledge base then needs to be made available to participants. At the same time, the convening organization needs to move away from an environment where information is simply disseminated, to one where information is gathered and converted into knowledge. Organizers need to accommodate

> both scientific and experiential knowledge; recognize that people have preferred forms of information exchange and delivery systems; understand that various sources of information are viewed as more credible than others; and realize the degree of risk (uncertainty) associated with knowledge about a problem is highly relevant. (Shindler and Cramer 1999, p. 32)

5. *Evaluate the sponsoring agency's organizational structure to determine its willingness to accept and act on knowledge gained through the participation effort*. Agency leadership must make a continual effort to assure their personnel that broader public involvement is considered desirable and essential to the organization's success and ultimate survival (Shindler, Brunson et al. 2002).
6. *Build in procedural fairness*. Public perceptions of procedural fairness in the decision-making process have as much effect on overall satisfaction as the decision's substantive outcome (Lawrence, Daniels et al. 1997). Inattention to these norms can result in losing trust and outcome legitimacy, while positive feelings towards the process can directly increase acceptance and compliance with a decision and, moreover, influence how citizens feel about the decision makers (Korsgaard, Schweiger et al. 1995; Shindler, Brunson et al. 2002). In addition, public participation research indicates that if people perceive procedures as fair, they are more likely to perceive the outcome as fair—even if it does not meet their desires (Lind and Tyler 1988; Korsgaard, Schweiger et al. 1995; Shindler, Brunson et al. 2002).
7. *Active, two-way communication should take place throughout the process*. Often called "authentic discourse," the deliberation process must accommodate a genuine opportunity to explore preferences in a manner that is not manipulative, deceptive or coercive.
8. *Monitor and evaluate the participation effort's effectiveness*. Information should be gathered through multiple methods, and should be in descriptive text format rather than simply checklists or bullets, in order to enhance learning for subsequent projects. In both internal and external evaluation, it must be accepted that participant feedback is as important as scientific feedback (Shindler, Cheek et al. 1999).

Because the literature does not confirm that all participation efforts exhibiting the above characteristics will be considered successful in terms of enhanced public support for the ultimate decision, **these appear to be necessary but not sufficient conditions for success**. To understand why not all participation efforts succeed, it is helpful to consider the participation efforts undertaken in the Sierra Nevada.

PARTICIPATION EFFORTS IN SIERRA NEVADA FOREST MANAGEMENT

While efforts to modify the Sierra Nevada Forest Plan date to the early 1990s, we focus here on planning efforts since summer 1998. As documented in Chapter 4, on July 10, 1998, the Regional Foresters of Forest Service Regions 4 and 5 committed to develop a new management direction for the national forests in the Sierra Nevada and Modoc Plateau. This new direction involved extensive public involvement beginning in September 1998, prior to issuing the Notice of Intent to amend the Land and Resource Management Plans for national forests in the two regions. Meetings and workshops were held throughout the affected regions so that individual citizens, private groups, tribes, elected officials and public agencies could provide their perspectives to help frame the purpose, need and proposed action for the Final Environmental Impact Statement (FEIS). According to the Forest Service:

> In an effort to more fully involve the public in the planning process for the Sierra Nevada Forest Plan Amendment, several meetings and workshops were conducted. These were designed to not only share information with the public, but also opportunities for dialogue among interested parties on those issues that they believed needed to be addressed in the Environmental Impact Statement. Once the Draft EIS was completed, a series of public meetings were held throughout the Sierra Nevada, Modoc Plateau, and in Los Angeles, the San Francisco Bay Area and Sacramento. These meetings were designed to engage the public in discussion around the alternatives, to determine what they believed should be included and what needed to be changed or eliminated. A public hearings format was seldom used because the desire was to engage in active, meaningful discussion, not just provide a forum for venting personal biases. With the new planning regulations, the Forest Service will continue its efforts to work in a collaborative process, recognizing that there are always new ways to undertake this endeavor. (USDA Forest Service 2001a, vol. 5, chap. 1, pp. 27-28)

A series of special meetings were also held with tribal groups, including a Sierra Nevada tribal summit in September 1998, and at least six other meetings around the state. A statewide planning meeting was held in Davis, California in October 1998. In addition, the USDI Fish and Wildlife Service, the U.S. Environmental Protection Agency, and other state and Federal agencies were active participants in the work leading up to the FEIS. Fish and Wildlife personnel were also part of the interdisciplinary team leading much of the developmental work. Note that this collaborative effort was completed prior to developing and analyzing alternatives, and was important in identifying key issues facing the Sierra Nevada.

In November 1998, the two regions published a Notice of Intent to prepare an Environmental Impact Statement in the Federal Register, beginning a 60-day formal public scoping period. During the scoping period, additional public information meetings and workshops were held, along with continuing consultations with Native American tribes. About 3,500 comments were received and analyzed to help develop alternatives for the EIS. In the end, eight of the nine alternatives considered, including the option ultimately selected, had their roots in input provided by groups external to the Forest Service.

The comment period on the Draft EIS began May 5, 2000. More than 5,500 copies of the document were distributed and nearly 60 meetings were held during the 77 days between May 23 and August 8, 2000. According to the Forest Service:

> To the extent they had the resources and expertise, personnel in local Forest Service offices held meetings at times and locations that, in their judgment, best met the needs and expectations of people in the area. In some situations, only one meeting was held in a given location. In other situations, two meetings were held in a given location. The first was often informational in nature, and the second provided more opportunity for dialogue among participants. When personnel from local offices were unable to answer questions about the Draft EIS, they did

> their best to follow-up later with additional information obtained from personnel on the EIS team. (USDA Forest Service 2001a, vol. 5, chap. 1, p. 27)

Publishing the Draft Environmental Impact Statement resulted in approximately 47,000 comments received, reviewed and reflected in the Final Environmental Impact Statement and Record of Decision (ROD). These comments were viewed by the Forest Service as a means to determine whether issues had been addressed adequately, displayed clearly, and understood by the public (USDA Forest Service 2001a, vol. 5, chap. 1, p. 22).

> The Forest Service does not view public comment as a vote to select an alternative. The public comment is an opportunity for people to gain a better understanding of proposed alternatives, to offer suggestions for improving or modifying those alternatives and to point out errors or omissions in the analysis. It is the Regional Forester's responsibility to make a well-informed, well-reasoned decision from all the information available, including public comment, science, law and regulation. (USDA Forest Service 2001a, vol. 5, chap. 1, p. 25)

The ROD was signed January 12, 2001. In April of the same year, the National Association of Forest Service Retirees issued a report critical of the decision. In the same month, the Forest Service received 276 appeals (only 234 of which were received by the requisite deadline). Eighteen requests to intervene were filed by interested parties or potentially affected persons or organizations. At the time, this was the largest number of appeals ever received by the Forest Service on a specific project. In response, the Chief of the Forest Service issued a decision on November 16, 2001 affirming the ROD but directing that the Regional Forester review elements of the decision along with concerns raised by the appeals.

While not specifically charged to seek broad public participation, the Review Team created by the Regional Forester made a concerted effort to solicit local community perceptions on the ROD. The California Regional Council of Rural Counties worked with the Review Team to schedule three "public workshops/meetings to explore the relationship of the National Forests to the small rural communities" in the region(USDA Forest Service 2003, p. 84). In addition, between April 2002 and December 2002 the Review Team held a number of "town-hall style meetings, workshops, presentations and field trips" (USDA Forest Service 2003, p. 85). Of particular interest is the Review Team's description of one such effort held in Quincy on April 29, 2002:

> The Regional Council of Rural Counties (RCRC) sponsored a full day event that included a field trip and town hall meeting. Both were intended to provide a local perspective on the impacts to northern rural communities as a result of the SNFPA, and on the effects of implementing the Herger-Feinstein Quincy Library Group (HFQLG) Pilot Project. The morning field trip included sites where fuels treatments under CASPO prescription (30" diameter limits) were compared with fuels treatments under the Framework and discussions ensued as to the ability to meet the fuels treatment objectives under the SNFPA. The afternoon and evening provided an opportunity for 200+ local residents, local officials, federal and state congressional staff, forest science professionals, and conservation leaders to present issues relating to implementation of the SNFPA to the Regional Forester

and Review Team. Three panels, a roundtable, and an open forum provided valuable learning opportunities:

- The panels provided knowledgeable local perspectives on the relationship between the SNFPA and the HFQLG, local social and economic impacts, interpretation of spotted owl data, and fire history and behavior.
- Community roundtable discussions on the focus areas of the Review provided an excellent opportunity for clarification and validation of the specific issues around community impacts that the Team should further investigate.
- An Open Public Forum allowed members of the public to comment directly to the Regional Forester and Team about impacts of the SNFPA. Personal perspectives from members of the audience were provided. The predominant theme voiced from local individuals and families dependent on the forest products industry, was one of moderate to severe impacts on family lifestyles and finances. (USDA Forest Service 2003, p. 85)

This description exemplifies the fact that throughout the development of the DEIS, the FEIS, and the most recent review effort, the Forest Service has made a concerted effort to solicit public participation and incorporate public priorities in their decision process. While the quality of facilitation across the many meetings and forums inevitably varied, it is beyond this report's scope to assess whether the Forest Service's participation efforts incorporated all eight public participation attributes described above. Our research does suggest that the Forest Service employed the best available methods to enable and evaluate public participation. And yet the process resulted in the highest number of appeals on record, and there is no indication that the degree of controversy has declined as a result of the review process or the level of public participation.

It seems that although the best available public participation techniques and methods known at the time were used, efforts to both include and satisfy a substantial majority of stakeholders fell short in the context of the Sierra Nevada Forest Plan Amendment process. We suggest that this is not the Forest Service's failure, but rather an indication that traditional approaches to public participation do not work well in this—or other similar large-scale wicked problem—contexts. The next section offers some possible explanations why this might be so.

LOOKING TO THE FUTURE

According to participatory theory, resolving complex problems in practice requires approaches that are:

- acceptable to all stakeholders,
- practical to implement,
- technically feasible,
- economically sustainable, and
- politically achievable.

The National Research Council (NRC) suggests that when confronting complex, multi-stakeholder social or environmental problems,

> The National Research Council suggests that when confronting complex, multi-stakeholder social or environmental problems, scientific risk assessment and risk characterization should be combined with broad social participation in an iterative, "analytic-deliberative" process (Stern and Fineberg 1996).

scientific risk assessment and risk characterization should be combined with broad social participation in an iterative, "analytic-deliberative" process (Stern and Fineberg 1996) . Under this approach, stakeholders, including experts and non-experts, work together to characterize and determine appropriate responses to risk by integrating scientific, social, ethical, and political inputs to decision making.

Participatory processes often lead to developing *temporary*, ad hoc stakeholder associations that come together to address specific issues. Yet attaining the necessary levels of trust and understanding to confront complex policy dilemmas requires *sustained* attention and involvement from the earliest stages. To establish this essential participatory infrastructure, the NRC committee proposes relying on developing "learning networks" (Senge 1990; Stubbs and Lemon 2001) of stakeholders to create a cooperative decision-making environment in which trust, understanding, and mutual reliance develop over time (Stern and Fineberg 1996).

In the learning network process, analysis and deliberation build on each other in iterative cycles. This analytic-deliberative approach requires engagement by both scientists and public stakeholders. The process is driven by a "feed-forward" mechanism in which stakeholders determine what is socially relevant or acceptable given the best science, and science helps strengthen stakeholders' grasp of technical issues. Analysis allows participants to develop and draw from a common, scientific knowledge base that informs deliberations. Deliberation in turn allows a policy consensus to emerge that is both socially and scientifically acceptable.

Unfortunately this process is not a panacea. Since participatory policy analysis democratically integrates various types of information—including quantitative and qualitative, analytical and perceptual, and objective and subjective—it can be highly demanding of social resources, including time, money, and stakeholder commitment. As our review suggests, it is quite easy for such processes to get derailed, and there are many more instances of failed processes than of successful ones.

Several aspects of large-scale wicked problems make successful participatory processes problematic. First, both the public and agency decision makers tend to seek optimal scientific, if not political, solutions. But when confronted with a wicked problem, such a search is futile. In the context of wicked problems, therefore, searching for an optimal solution should give way to efforts that strive more realistically for mutual "satisficing." In contrasting optimizing behavior with satisficing behavior, Simon (1997, p. 295) explains,

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> A decision maker who chooses the best available alternative according to some criteria is said to *optimize*; one who chooses an alternative that meets or exceeds specified criteria, but that is not guaranteed to be either unique or in any sense the best, is said to *satisfice*. (emphasis added)

Thus "satisficing" is searching for broadly acceptable and implementable solutions, rather than for optimal solutions that may be difficult to implement. Again, optimal solutions generally either do not exist or cannot be identified in advance for wicked problems.

Second, as noted in Chapter 6, there is the issue of scale itself. Successful participation efforts have almost always been local in nature (Shindler and Cheek 1999). Indeed, Fiorino (Fiorino 2000) sees this as a defining characteristic of the new era of environmental management. Yet the Sierra Nevada's eleven national forests comprise over 11,000,000 acres—an area larger than nine states. All of wicked problems most difficult aspects are accentuated when the scale is increased to this level.

The Sierra Nevada Forest Plan Amendment (SNFPA) process has incorporated numerous opportunities for public engagement, including both public meetings and formal periods established for public comment. Public participation in the Sierra Nevada case shows marked improvement over the situation in many past governmental decision-making processes. During FEIS development, for example, stakeholder groups had the opportunity to develop alternative management strategies that were considered in detail. Moreover, SNFPA documents repeatedly refer to the importance of "transparency" and "public involvement." For example, the recent Review Team report states:

> The year-long review has been an open, transparent and highly collaborative process by local Forest Service employees working with a host of key stakeholders, including elected officials, tribes, interest groups and other government agencies. Insight was obtained from dozens of public meetings, workshops and field trips held with employees, interest groups, scientists, other government agencies, journalists and others. Biweekly updates were given to key stakeholders. (USDA Forest Service 2003, Executive Summary)

Over the past 10 years, the Forest Service's Pacific Southwest Region has significantly expanded the boundaries of public participation. While retaining ultimate decision-making responsibility as required by law, Forest Service administrators have strengthened opportunities for concerned citizens and stakeholder groups to participate in developing alternative forest management plans and to comment on alternatives under consideration. We find the Region's decade of efforts commendable.

Four Options

As the Region looks to the future, it is worth noting that recent trends in the literature call for still richer public engagement in environmental management, particularly in the case of wicked problems. Both the Stage III risk communication strategy described in Chapter 2 and the analytic-deliberative decision model described above are examples of new approaches to public participation and deliberation being proposed.

However, in the case of wicked problems, this call for even more participation may not be enough to assure an implementable decision in the future. Wicked problems are characterized by a high degree of uncertainty and perceived risk, and a lack of public

consensus on the solution. In such an environment—and given their already substantial efforts to include the public—four options are available to the Forest Service.

Option 1: Stop Trying

The Forest Service could simply give up on participation at the unwieldy scale required by the SNFPA process. Neither current law nor public sentiment will allow such a decision.

Option 2: More of the Same

The Forest Service could accept the call for even more stakeholder involvement by further increasing the amount and improving the quality of participation. We acknowledge and applaud the Forest Service's efforts in applying state-of-the-art participatory processes and management techniques for dealing with risk and uncertainty over the past decade in the Pacific Southwest Region. However, the fact that their efforts resulted in 234 formal appeals strongly suggests that there is still widespread dissatisfaction with the process. In the Pacific Northwest, studies from forest communities show that citizens recognize that the Forest Service now solicits more public comments, but believe the agency does not use this input in forming management plans (Shindler, Brunson et al. 2002). In a separate longitudinal study of residents in the Blue Mountains of eastern Oregon and Washington, researchers found that despite the agency's significant public engagement efforts, the relationship between the Forest Service and the residents appears to have eroded (Shindler and Toman 2003). Thus we see no reason to believe that simply doing more of the same kinds of activities will solve the problem of low public support.

Option 3: Shift the Decision Burden to the National/Political Level

The Forest Service could take the position that wicked problems—like managing the Sierra Nevada—are essentially political problems and therefore can only be addressed in the national political arena. Conflict around problems with such broad impact and active national interests are precisely why there is a national political process. While there is a great deal to be said for this perspective, we believe there is a fourth option available which holds significant promise for addressing large-scale wicked problems like managing the Sierra Nevada—without abdicating the important role of Forest Service managers.

Option 4: The Learning Network Process

Both the National Environmental Policy Act (NEPA) and the National Forest Management Act (NFMA), key laws affecting the Forest Service decision process, mandate public participation but provide little guidance as to how that participation is to occur and what role the public has in the ultimate decision. Historically, "public participation" has been interpreted to mean providing opportunities for the public to comment on proposed federal actions that may impact the environment. In the Sierra

Nevada case, the Forest Service has gone far beyond this minimal level of public participation. At the time this level of public participation was unprecedented in federal land management planning.

NEPA and NFMA do make it clear that it is a federal official who is responsible for making the decision. The decision maker cannot delegate this authority to any outside individual or group. Further, the decision maker must balance legal mandates and regulations, budget realities, public desires and expectations, and biological limitations in reaching a decision, guided by the values and risks at stake. This is especially difficult in the case of wicked problems where the science is uncertain and there is no consensus on public desires and values. It is also clear that the decision maker's personal values play a role in the final decision. In fact, according to the Forest Service, defining acceptable risks is part of the manager's job (USDA Forest Service 1997).

Recognizing that managing the Sierra Nevada is a wicked problem is important to arriving at an appropriate characterization of the challenges facing the Forest Service in the future. One immediate implication is the recognition that there will be no optimal solution to the problems faced. No amount of scientific or analytical effort will produce a solution that addresses, with sufficient certainty, all the critical ecological and political aspects of the management problem for all stakeholders. Instead, the most productive approach for dealing with wicked problems will be to seek broadly satisfactory, rather than optimal, solutions. A satisfactory solution in this context implies one that is consistent with ecological and legal constraints—and is also acceptable to the public. We characterize this approach as "collective satisficing."

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Since there is no optimal solution to the Sierra Nevada management problem, the Forest Service's greatest short-term risks are related to decision processes rather than ecological outcomes. The SNFPA dilemma is a wicked problem characterized at all levels by multiple risks and uncertainties. Both the scholarly literature and best practices from a number of environmental management arenas indicate that the best approach for dealing with such decisions is to develop a decision process that tightly integrates the best scientific analysis and the fullest possible public participation and deliberation.

The participatory approach we suggest incorporates the key aspects of the Forest Service's NEPA and forest-planning processes. The planning process is typically driven by identified issues that determine the scale and nature of the analysis and decision. The suggested "learning network" process (Figure 14) begins with identifying issues (Step 1), but also—at the outset—formally seeks to identify stakeholder values and preferences about these issues (Step 2). The literature clearly indicates that care must be taken in

identifying and engaging stakeholders. Stakeholders must represent a broad range of interests, have a long term commitment to the effort, and have credibility with other individuals and interests interested in, but not directly engaged in, the process.

Information about stakeholder preferences and values could then be used as important input in developing a modeled set of alternatives that are environmentally, economically, and technically feasible and also reflect the range of stakeholder preferences and values (Step 3). This step is motivated by the observation that there are generally a very large number of technically feasible potential solutions, not just the relatively small number usually displayed in a Draft or Final Environmental Impact Statement. Further, since there are no perfect solutions to wicked problems, only those that are more satisfying or more useful than others, it will be important to find solutions that allow the agency to move forward in an adaptive management mode with a broad base of public support. Therefore, the alternatives developed in Step 3 should be analyzed only to the extent that they can be useful to stakeholders in further refining their preferences in Step 4.

Stakeholder reactions to the alternatives might then used in an iterative, analytical process to define a small set of feasible alternatives, perhaps three to five, that best satisfy public preferences and values (Step 5). This set of alternatives could then be fully analyzed and subjected to the NEPA process, and a decision made (Steps 6, 7, and 8). The decision would then be implemented, and a combination of monitoring results from implementation and small-scale experiments, jointly identified by stakeholders (managers, public interest groups, and scientists) to answer specific questions, could be used to provide feedback (Steps 9 and 10) to identify new issues and opportunities for further progress. One consideration that could foster understanding and the building of trust would be to use third party monitors or stakeholder monitoring.

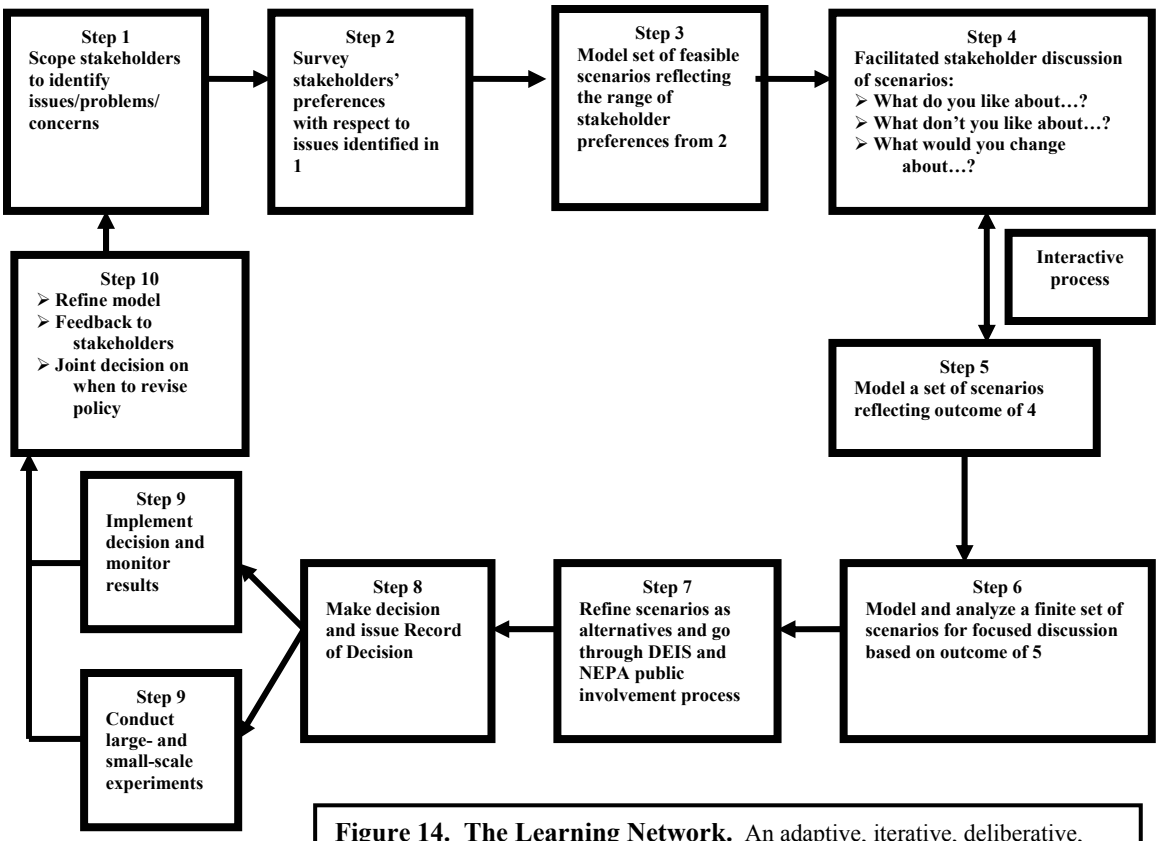
Step 1
Scope stakeholders to identify issues/problems/ concerns
Step 2
Survey stakeholders' preferences with respect to issues identified in 1
Step 3
Model set of feasible scenarios reflecting the range of stakeholder preferences from 2
Step 4
Facilitated stakeholder discussion of scenarios:
What do you like about…?
What don't you like about…?
What would you change about…?
Interactive process
Step 5
Model a set of scenarios reflecting outcome of 4
Step 6
Model and analyze a finite set of scenarios for focused discussion based on outcome of 5
Step 7
Refine scenarios as alternatives and go through DEIS and NEPA public involvement process
Step 8
Make decision and issue Record of Decision
Step 9
Implement decision and monitor results
Step 9
Conduct large- and small-scale experiments
Step 10
Refine model
Feedback to stakeholders
Joint decision on when to revise policy

Figure 14. The Learning Network. An adaptive, iterative, deliberative, analytical, participatory process for natural resource decision making in a wicked problem environment built upon the USDA Forest Service NEPA and NFMA planning process.

This Learning Network process more explicitly models stakeholder preferences, and uses these preferences to develop and assess initial alternatives. Modeling preferences would allow the Forest Service to assess the values and preferences of a broad cross-section of stakeholders. Explicitly linking those preferences to the science models used to generate alternatives will likely sample a much broader range of alternatives, and will increase the likelihood of identifying alternatives which offer the greatest promise of being broadly acceptable.

CONCLUSION

This chapter has reviewed the best current thinking on public participation in addressing wicked environmental and forest management problems. In addition to documenting the need for participation, and enumerating eight necessary characteristics of successful participation efforts, we have argued that the SNFPA process did indeed exhibit many of the best attributes called for in the literature. Nonetheless, the process resulted in a very high rate of appeals, suggesting the goal of greater public support for the final decision was not fully achieved.

While some may argue that the Forest Service's strong efforts to include the public could be further expanded and improved, we suggest that when dealing with wicked problems on the scale of the Sierra Nevada, there are severe limits to the public participation's contribution *as currently conceived*.

Our informed suggestion: Rethink the way participation is used in the future, incorporating a more formal assessment of values and preferences into a modeling effort that links models of public preferences to biological and fire models from the forests in question. Such an effort will not replace traditional public participation; rather, it will render the learning from such efforts more systematic, and the alternatives ultimately considered more broadly acceptable.

APPENDIX TO CHAPTER 7: EIGHT DESIGN CONSIDERATIONS FOR SUCCESSFUL PUBLIC PARTICIPATION

This appendix offers a detailed discussion and description of the eight design considerations deemed necessary for successful public participation, based on reviewing relevant literature.

1. THE AGENCY MUST COMMIT TO PARTICIPATION

Public participation efforts often fail because the convening organization was not willing to make the essential commitments to assure success.

- Is the agency willing to commit the time and resources necessary to make a participation effort successful?
- Are they are willing to be flexible and open-minded, and recognize the legitimacy of different public values and concerns?

If the agency cannot commit to these requirements, they are better off not convening a participatory effort, and should strive instead to meet the minimum statutory requirements (Beierle and Cayford 2002).

2. IDENTIFY AND ENGAGE APPROPRIATE STAKEHOLDERS

Once the agency has committed to move forward with a participatory initiative, it must next address the question, "Who is the public for this issue?" Defining stakeholders can be an extremely complex process, but a necessary one, and can have serious consequences for the participatory effort's success. Research indicates that efforts leaving out stakeholders are less effective and less likely to succeed in implementation (Gray 1989). Also, to deny access to a particular position or argument—even if considered racist, prejudiced, or sectarian—may sabotage the effort and denies deliberation's efficacy, which advocates assert will ultimately rule out unjust or bad arguments (Gray 1989; Dryzek 2000). Even if meetings are contentious, interaction provides an opportunity to gain insight into other values and perceptions, and is therefore a valuable experience itself. It provides a beneficial cumulative effect: As participants get to know each other better they are more likely to relax their positions and find common concerns (Shindler and Neburka 1997). Dryzek (2000, p. 169) asserts, "Discursive democracy is not an exclusive gentlemen's club." The following three considerations are part of stakeholder identification:

- The Effort's Scope. Broader issues demand a broader spectrum of participants, especially where there are trust issues or conflict involved; narrower issues might only require including a few affected individuals (Blahna and Yonts-Shepard 1989; Beierle and Cayford 2002).
- Representation. Organizers also need to assess the type of stakeholder representation that is appropriate for the participatory effort. For example, public officials usually must choose between "participants who are representative in terms of the various interests affected by an issue[,] or

representative in terms of socioeconomic characteristics (e.g., age, race, education, and income" (Beierle and Cayford 2002).

- Level of Influence. As demonstrated by Arstein's (1969) ladder of participation, the amount of power stakeholders share in the decision-making process varies along a continuum. Process planners and managers must consider how much influence the participants should be given to effectively accomplish agency goals, and then choose the appropriate participation mechanism to fit. If the goal is instrumental, perhaps to build trust, then organizers should convene a forum designating a high level of public influence since research indicates that increasing this factor is highly and significantly correlated with trust building (Beierle and Cayford 2002).

Often, some stakeholders will question the legitimacy of including other stakeholders in the participation effort. This is true both of government officials who may not perceive citizens as having enough scientific or technical expertise on the issue to participate effectively, and of stakeholder groups who discount other representatives' credibility or motives. Questioning others' intentions or their motivation for participating leads to failure. Therefore, the convener must thoroughly examine the issue dynamics—including history and prior relationships. The convener needs to understand the problem's impact on each stakeholder, and whether the stakeholder has the ability to halt or advance any negotiated solutions. In addition, the convener must determine the nature and strength of stakeholder interdependencies in order to help the participants realize mutually beneficial alliances (Gray 1989).

It may well prove difficult to organize and recruit a truly representative cross-section of interests on a wicked problem. Studies have shown that low-income populations are less likely to participate, while participants with better education and higher incomes tend to be overrepresented (Gray 1989; Thomas 1995; Beierle and Cayford 2002). Also, many participants who do become involved are spokespersons for special interest groups that do not necessarily represent citizens in general (Durning 1993; Fischer 1993; Thomas 1995; Beierle and Cayford 2002). Overrepresentation by these interest groups can further deter the general public from participating since they feel that their own interests are diminished by interest groups with more power or monetary influence (Shindler and Neburka 1997). Also, choosing "movers and shakers" who may not realistically represent the public interest may further contribute to the public's lack of trust, and decrease chances for a successful outcome (Boiko, Morrill et al. 1996). To further complicate matters, while more intensive collaborative processes such as negotiations and mediations are more likely to reach a successful outcome, they are less representative of the wider public than less intensive processes such as public meetings (Beierle and Cayford 2002).

The challenge for participation planners, then, is to "find ways to harness the problem-solving capabilities of intensive participatory mechanisms with the broad involvement of the public more often found in the less-intensive mechanisms" (Beierle and Cayford 2002). Beierle and Cayford (2002) recommend that

- participants be responsible for communicating back to their broader constituencies;
- public planners utilize a wide variety of different mechanisms to spur different interests; and
- participation initiatives begin to use the power of Internet participation forums to reach new stakeholders.

In come cases, stakeholder polarization may be too formidable to overcome because ideological differences are too great, one stakeholder has unilateral power to take action, constitutional issues are at stake or legal precedent is desired, previous interactions have not been successful, the problem is too threatening because of issue history, or because a legitimate mediator cannot be found or agreed upon. In these types of cases, conveners need to realistically assess the likelihood of being able to surmount the obstacles before committing to the participatory process (Gray 1989).

3. CLEARLY STATE OBJECTIVES FOR PARTICIPATION

The next question a convening organization or agency must ask is, "What do we hope to accomplish by involving the public?" Leaders must convince both their own organization and other participants that there is a need for change, which requires transparency and often brutal honesty about conditions known and unknown, and identifying current problem areas and failings (Drucker 1999). People are more likely to accept change if they have been engaged in a meaningful exchange and understand the real potential outcomes (Shindler, Brunson et al. 2002). Public managers also need to convey their reasons for the participation effort, accurately define their own role and the participants'; and then follow through on their commitments (Shindler and Neburka 1997). Stakeholders frequently report that they are more likely to trust public officials who candidly state their rationale for including them in decision-making, and then follow through with their commitments (Shindler, Brunson et al. 2002).

Determining the effort's expectations may also dictate which participation mechanisms should be used. For example, if the agency's goal is to reduce conflict and build trust, then the vehicle should provide for two-way communication and deliberative decision-making. If the goal is to share information, then a forum such as a public meeting or hearing would be best.

Timing is also an important up-front consideration. Issues that have not attained public exposure may be too early for a national-level deliberation effort, whereas issues in the implementation stage may be past the appropriate time to begin to include the public (Gray 1989). In the case of complex/wicked problems, ample evidence supports involving the public early in the process and keeping them involved steadily throughout (Blahna and Yonts-Shepard 1989; Smith, McDonough et al. 1999). All too often, however, there is a gap in public inclusion between policy planning and implementation's early and late stages.

For example, in a large study involving 13 geographically diverse forests, Blahna and Yonts-Shepard (1989) found that all 13 forests made some effort to include the public during the first stage of planning, either through mailed information, public meetings or workshops, or requests for comments. All 13 forests also attempted to include the public during late-stage planning, after the draft plan and environmental impact statement were released, using communication vehicles such as news releases, public and group meetings, and requests for comments. However, only 1 of the 13 forests made an active effort to include the public during the middle stage of planning, when designing and planning alternatives were actually occurring. Since the middle stage averaged between 4 and 6 years—versus the relatively short 6 to 9 month period of the first stage, and the last stage's 9 months to 1 year—it appeared to be a major shortfall in the process, and apparently disenfranchised the public during the longest period of time when key planning decisions were being made. Not surprisingly, comparing the one forest that had made an active participation effort during the middle stage to a forest that had made no effort during the middle period found the two on opposite ends of the conflict continuum—highly favoring the inclusive participatory effort.

4. ASSESS NECESSARY KNOWLEDGE LEVELS

The next question public planners need to ask themselves is "What does the public need to know to participate effectively?" "Providing information" to stakeholders is often misconstrued as increasing public knowledge, understanding, and acceptance. Traditionally, public managers have used jargon-filled, one-way modes of information transfer as the primary means to "educate" the public (Lawrence, Daniels et al. 1997). Generally, if the public understood why the decisions were made, they would most likely accept the decisions. However, one-way communication modes are usually seen by the public as a sales pitch for a decision that has already been made. Citizen surveys indicate that public meetings and hearings—the most commonly used one-way participation vehicles—are negatively regarded as "decide, announce, and defend" types of communication (Smith, McDonough et al. 1999).

Enhancing public knowledge involves more than simply providing information. As Shindler, Brunson et al. (2002, p. 34)argue, "Information alone is rarely sufficient to produce change." In fact, poor information delivery can diminish public acceptance of a policy and further weaken trust (Shindler, Brunson et al. 2002). Public planners should recognize the complex interaction of factors, such as personal experience, social norms, affective reactions, and cognitive beliefs, that influence people's responses and risk perceptions (Slovic 2000). The convening organization needs to move away from an environment where information is simply disseminated to one where information is gathered and converted into knowledge. Agencies need to accommodate

> both scientific and experiential knowledge; recognize that people have preferred forms of information exchange and delivery systems; understand that various sources of information are viewed as more credible than others; and realize the degree of risk (uncertainty) associated with knowledge about a problem is highly relevant. (Shindler and Cramer 1999, p. 32)

Sufficient knowledge of an issue encourages participants' movement toward shared understanding, effective communication, increased capacity to innovate, enhanced efforts to reach a mutually acceptable solution, and improved stakeholder relationships (Lauber and Knuth 1998).

In addition, the general public has commonly felt that educational information provided by public institutions is too technical and not sufficiently inclusive of diverse values (Smith, McDonough et al. 1999). Even in problems involving complex science and uncertainty, citizens can become knowledgeable and technically proficient (DeLeon 1995). Participatory efforts must provide an opportunity for informed debate to achieve a level of understanding the issue's complexities, which includes "known causes and effects, consequences of choices, and long-term implications" (Stankey 1995; Shindler and Cramer 1999). Conveners also need to incorporate the most recent and trustworthy scientific/technical information available into the process to create or enhance their credibility (Shindler and Neburka 1997). However, they must allow the group to analyze the information together rather than filtering it unilaterally. They must also extend common courtesies such as providing advance materials for review, providing understandable definitions of terminology, and providing quick and direct question responses. In several studies, agency personnel have reported that this type of approach even helped them learn about their own data (Shindler and Neburka 1997).

5. EVALUATE THE SPONSORING AGENCY'S ORGANIZATIONAL STRUCTURE

Bureaucracies' size and history are often significant barriers to change (Korten 1981). Some agencies have been reluctant to adopt a decentralized, participatory decision-making paradigm, continuing to make decisions largely with minimal public consultation and to use management practices that have not integrated issues' social aspects (Shindler and Cramer 1999). Their personnel are often compartmentalized, receiving exposure to only a small portion of the overall policy issues since research methodologies generally do not incorporate a holistic philosophy, instead separating a problem's socioeconomic and biophysical aspects without acknowledging critical cross linkages (Cortner and Shannon 1993). In addition, optimization is still the dominant goal, and rational tools such as cost benefit analysis and risk assessment usually trump more democratic decision-making measures. In short, efficiency is rewarded, not innovation.

Overcoming resistance to innovation—often attributable to the uncertainty involved with change—requires a priority commitment from the top down, supporting public participation initiatives as part of the organizational ethos (Gray 1989; Frentz, Voth et al. 2000). Personnel may have an investment in the status quo, perceiving collaboration as draining resources and wasting their human capital. They may not understand or agree with consequences associated with the change, wish to avoid controversy, or worry that public participation initiatives will cause their organization to lose power and influence (Gray 1989; Selin and Chavez 1995). Also, there may be limited direction available as to how to administer effective public participation initiatives (Blahna and Yonts-Shepard 1989).

Leaders must therefore make a continual effort to assure their personnel that broader public involvement is considered desirable, and essential to the publicly-funded organization's success and ultimate survival (Shindler, Brunson et al. 2002). They must also require collecting knowledge gained through each initiative in order to begin to build policies and procedures to support the public inclusion requirement in institutional decision making.

Public organizations must develop the capacity to respond to public concerns with an enterprise-wide commitment shown through leadership and action. Management practices must move away from autocratic control and intricate preplanning to a more lateral organizational structure that allows for flexible policies and procedures, and tolerates uncertainty and ambiguity (Korten 1981; Gray 1989; Selin and Chavez 1995). Management must also provide for greater flexibility in personnel risk taking, experiment with collective decision-making initiatives, and "encourage, reward, and provide time available" in order to engage in participation initiatives and to build institutional knowledge (Selin and Myers 1995). Ideally, assigning a liaison whose sole purpose is to bridge the relationships between the institution and the other stakeholders is highly recommended (Frentz, Voth et al. 2000).

In order to facilitate the aforementioned organizational changes and build a capacity to learn, the organization must employ a systematic process that allows for organizational learning and adaptation through error and unpredicted outcomes. This will require training programs to educate and re-educate personnel about the advantages of participatory approaches, and to provide necessary skills for personnel to facilitate participation and communicate effectively. The organization will also need to develop guidelines and procedures to determine when and how to use public participation, institute reward mechanisms to encourage collaborative initiatives, implement performance measurements to track results, and build systems to incorporate lessons learned and knowledge gained. In addition, the organization must aggressively apply its legal authority to include the public in its decision-making capacity and to seek more statutory devices if necessary to require further agency collaboration (Frentz, Voth et al. 2000).

Other organizational requirements for successful collaboration include adequate funding structures, and interagency cooperation to cultivate better relationships with other organizations in the chain in order to provide greater opportunities for learning and seamless integration (Frentz, Voth et al. 2000).

Research indicates that there is usually no continuity of public personnel through all phases of the participation process (Gericke, Sullivan et al. 1992). Often, planners and implementers are different, in addition to recurrent changes in scientific and technical support personnel. This overall lack of continuity diminishes trust in the effort's authenticity and can seriously affect the group's ability to be successful (Gericke, Sullivan et al. 1992). In addition, a public leader's departure is often correlated with participation effort failure (Shindler, Cheek et al. 1999). Participation planners must be cognizant of these effects and make a commitment to try to ensure personnel continuity

as much as they feasibly can. However, success can be maintained even with losing a lead person if the replacement person has a similar leadership style and the replacement occurs fairly quickly (Wondolleck 1988).

6. BUILD IN PROCEDURAL FAIRNESS

Public perceptions of procedural fairness in the decision-making process have as much effect on overall satisfaction as the decision's substantive outcome(s) (Lawrence, Daniels et al. 1997). Being inattentive to these norms can result in losing trust and outcome legitimacy, while positive feelings towards the process can directly increase acceptance and compliance with a decision, and influence how citizens feel about the decision makers (Korsgaard, Schweiger et al. 1995; Shindler, Brunson et al. 2002). In addition, public participation research indicates that if people perceive procedures as fair, they are more likely to perceive the outcome as fair—even if it does not meet their desires (Lind and Tyler 1988; Korsgaard, Schweiger et al. 1995; Shindler, Brunson et al. 2002). Based on these findings, it is critical that the public manager build a participation model based on procedural justice principles. It is also vital to actively seek to enhance their facilitation skills with training that provides guidance on how to understand and respond to different perspectives and values with an open mind.

Personal trust revolves around honesty and reciprocity, while organizational trust builds on procedural equity (Shindler, Brunson et al. 2002). Over the short term, building trust using procedural fairness may take time and compounded efforts to overcome historical mistrust, but there is a positive cumulative effect from each effort (Lind and Tyler 1988). Also, research has shown that a process focus is especially useful with wicked problem decision making because it encourages collaboration, increases decision acceptance, and lessens the likelihood of delays through appeals and lawsuits (Wondolleck 1988).

Decision makers too often concentrate on public acceptance of a decision without realizing that the process may be more important than the outcome (Shindler, Brunson et al. 2002). Shifting from an *outcome* orientation to a *process-and-outcome* approach reallocates the group's focus from the question, "What should be decided?" to the question, "How will the decision be made?" (Wondolleck 1988). In other words, procedural fairness in not simply a means to an end—it is an end in and of itself. Programs that consciously strive to make inclusive, quality decisions and that focus on group fairness principles in the process will yield higher levels of public satisfaction (Lawrence, Daniels et al. 1997).

Significant inequity in stakeholder power distribution is a formidable characteristic that must be overcome since stakeholders will only participate if they believe they have roughly equal opportunity to affect the decision or outcome (Gray 1989; Selin and Chavez 1995; Dryzek 2000). When one party holds more power, other parties may feel they have more to gain through other measures than participation—such as litigation (Gray 1989; Cortner and Shannon 1993). However, simply allowing people to air their concerns is not enough. Dryzek (2000) states that all participants must have an equal opportunity to affect the outcome, or the process will not be deemed fair, and trust in the

organization will be lost (see Consideration 7 for more on this point). Involvement without consideration may be more harmful than no involvement, since it creates frustration, which increases resentment and distrust (Korsgaard, Schweiger et al. 1995). "Authentic democracy can then be said to exist to the degree that relative preferences influence collective outcomes" (Dryzek 2000).

To help achieve a balance of power, the group must collectively ratify a process that includes ground rules that allow stakeholders to believe their interests will be protected and advanced throughout the process (Gray 1989). The institutional decision maker must be regularly involved in the participation effort in order to project to members that the effort is legitimate and that their input is important and will be taken seriously (Shindler and Neburka 1997). This is a radical departure from tradition: managers who have a substantial amount of discretionary authority are only likely to be involved with large, one-way communication types of participatory mechanisms such as public meetings, whereas planning staff, who are not typically given very much discretion, are most likely to be involved with collaborative activities (Gericke, Sullivan et al. 1992). "A well conceived and executed public participation effort may have little effect on the number of appeals filed if individuals or groups perceive that they had insufficient influence" on the decisions that were made (Gericke, Sullivan et al. 1992).

As facilitator, the public official must be cognizant of possible or perceived breeches of procedural equity in order to resolve the issue before group trust is violated (Gray 1989). In addition, the group leader or facilitator must genuinely acknowledge participant input with attentive listening, patience, and empathy in order to affirm that their values are respected and that their status in the group is important (Korsgaard, Schweiger et al. 1995). Considering input has a positive influence on a participant's sense of group attachment, which is associated with increased cooperation and diligence to achieve goals (Korsgaard, Schweiger et al. 1995). This is especially important if the decision outcome is not what the participant would have preferred: considering input is even more important when influence is low (Korsgaard, Schweiger et al. 1995). "The results suggest that leaders may not need to relinquish control over decision quality to gain commitment and subsequent cooperation; they merely have to treat people fairly and with respect" (Korsgaard, Schweiger et al. 1995).

Research indicates that effective participation efforts include participants who are willing to abide by a group decision-making process to jointly identify the group's purpose and define task-oriented goals up front (Shindler and Neburka 1997). Disagreement over goals lessens participatory decision-making's usefulness (Sample 1993). Participants must know what they need to accomplish with measurement objectives set forth in order to maintain productivity and feel a sense of accomplishment. Failure to meet this requirement is often identified as an area of frustration and a factor of group failure (Shindler and Neburka 1997).

The following factors, many of which have already been discussed in other consideration areas, are important determinants of fairness perceptions (Leventhal 1980; Korsgaard, Schweiger et al. 1995; Lawrence, Daniels et al. 1997):

1. Decision consistency across people and time;
2. Decision-maker neutrality;
3. Accurate, informed data;
4. Ability and willingness to correct errors;
5. Including all affected stakeholders;
6. Authentic consideration of participant views;
7. Substantial influence on final decision; and
8. Compatibility with accepted social and ethical norms.

7. STRIVE FOR AUTHENTIC DISCOURSE

In order to be perceived as engaging in what is termed "authentic discourse," public managers need to move away from what has been referred to as the "three I's of federal public involvement: Inform, solicit Input, then Ignore" to a paradigm where the public can genuinely affect change (Shindler and Neburka 1997). In addition to ensuring that the participatory initiative is inclusive towards all affected stakeholders, that participants have adequate knowledge, that the organization supports collaborative efforts, and that there is procedural justice, conveners also must persuade and engage a discursive debate that includes active participation from all representatives who have agreed to participate (Stankey 1995; Shindler and Cramer 1999; Stubbs and Lemon 2001). Input from a wide variety of interests and actors builds the capacity for mutual learning on both the government's and the public's parts (Steelman 2001). This active, two-way communication effort needs to be incorporated throughout the planning and implementation process—not just during the early and late stages (Blahna and Yonts-Shepard 1989).

Dryzek (2000) argues that in order to be authentic, the deliberatory process must accommodate a genuine opportunity to explore preferences in a manner that is not manipulative, deceptive, or coercive. The convener must champion respect for stakeholder differences since they are the foundation for creative solutions (Gray 1989) . Using "agents of distortion" diminishes perceptions of equality among stakeholders, thereby reducing the likelihood of a successful outcome (Dryzek 2000). All forms of communication must have a rational justification—not an emotional justification—in order to guard against coercion (Dryzek 2000). As differences are articulated, common, underlying concerns will surface which may have been previously obscured by adversarial history or preconceived assumptions arising from stereotypes that cause selective listening and discount others' legitimacy (Gray 1989). Problem framing using guidance such as, "Let's explore the problem and work together to find a solution," rather than, "Which of the following alternatives would you prefer for solving the problem?" helps facilitate common understandings (Sample 1993).

Since research indicates a large portion of the public does not trust public officials, and consequently does not support their decisions or their decision-making processes, public managers need to approach trust building as the central, long-term goal of effective public participation (Fischer 1993; Shindler, Brunson et al. 2002). Public perceptions of government commitment result in greater trust and credibility than knowledge and

expertise (Peters, Covello et al. 1997). Keys to developing trust are to genuinely listen to stakeholder values and ideas, and to incorporate procedural justice principles into the decision-making process.

8. MONITOR AND EVALUATE

Until fairly recently, the measure of a good decision was its compliance with statutory and regulatory requirements and consistency with internal agency policy (Cortner and Shannon 1993). Selin, Schuett et al. (2000) argue that empirical meta-evaluation of collaborative efforts has been minimal; most information available consists of individual accounts of accomplishments. Under these conditions, "responsiveness to public desire was not only difficult but irresponsible" (Cortner, Shannon et al. 1996, p. 15)

Organizations must not only have processes in place to collect information from participatory initiatives and learn from them, they must also have the desire and capacity to incorporate institutional behavioral change to accommodate the learning (McLain and Lee 1996). Frequently participants complain that they did not accomplish much that they can see (Shindler, Brunson et al. 2002). Monitoring effectiveness, both internal and external, is fundamental to the participation effort's perceptions of success—and yet it is usually not coordinated, if at all, until an initiative's end (Selin, Schuett et al. 2000).

Internally, there needs to be an ongoing, collaborative effort among the group to carefully review whether the effort is meeting the goals and expectations, both scientific and social, set forth by the group in the beginning (Selin, Schuett et al. 2000). This continuous feedback loop should have the ability to accommodate learning, allowing for pragmatic adjustment as evaluation demands. There should also be a systematic, external monitoring capability in order to produce an accountability measure of the decision's success, and of the resources employed in the initiative. External review is also necessary to further enhance organizational learning for future benefit (Selin, Schuett et al. 2000).

Information should be gathered through multiple methods, such as discussions with participants, written records, minutes, and surveys, and should be extensively detailed in descriptive text format rather than simply through checklists or bullets in order to thoroughly confer learning to subsequent projects and personnel (Shindler, Cheek et al. 1999). In both internal and external evaluation, accept that participant feedback is just as important as scientific feedback (Shindler, Cheek et al. 1999).

Although public participation's record is not perfect, there is evidence that even when participants do not reach an agreement, they still give positive evaluations of the decision-making process. Two major criteria can be used by evaluators and other observers to judge a participatory initiative's success (Gray 1989):

1. Was agreement reached?
2. Was the agreement implemented?

Other evaluation criteria involve more subjective measures of success that should be gathered from participants through interviews and questionnaires:

- Does the outcome satisfy the real issues in question?
- Do the parties feel they affected the decision?
- Are the stakeholders willing and able to implement the decision?
- Does the decision produce joint gains for the parties?
- Was communication between the parties increased and [were] the working relationships improved?
- Has the decision held up over time?
- Was the process efficient in terms of time and resources?
- Does the solution conform to available objective standards?
- Do the parties perceive the procedures were fair?
- Did the procedures conform to accepted standards of procedural fairness? (Gray 1989, pp. 256-257)

While it would be satisfying to argue that all participatory efforts are adequately designed along these eight critical dimensions, such does not appear to be the case. We can conclude that the probability of success is enhanced if these characteristics are present. But particularly in the context of large-scale wicked problems, they appear to be necessary but not sufficient conditions for garnering public support.

CHAPTER 8. INTEGRATING SCIENCE AND PUBLIC PARTICIPATION THROUGH AN ENHANCED ADAPTIVE MANAGEMENT STRATEGY

The large literature on the nature of wicked problems and current alternative strategies to address wicked environmental and forest management problems do not lead to a simple management strategy. However, "learning networks" offer a potentially practical and implementable process to effectively incorporate both the best scientific understanding and the public's social and political values for a solution satisfactory to multiple and diverse stakeholders.

For forest managers, the **risks and uncertainties** inherent in managing the Sierra Nevada National Forests create unavoidable dilemmas that cannot be eliminated with better science alone.

Human decision making under natural and environmental uncertainty has existed ever since we made decisions on where to hunt or how best to avoid being hunted. What distinguishes a public decision maker's decision regarding human interaction with nature from the earliest humans are both the uncertainties' sources and the consequences' nature and scale. Clearly, experts have superior information regarding uncertainties in their own knowledge areas. But in describing and representing the scientific and stochastic uncertainties inherent in the Sierra Nevada Forest Plan management decision, analysts face a dilemma. On one hand, simple and accessible characterizations of the problem's multiple uncertainties are likely to be misleading, biased, or wrong. On the other hand, detailed characterizations of uncertainty are likely to be difficult to understand and communicate to stakeholders, and consequently may not be useful to the public or to decision makers. There is no scientific or technical solution for this dilemma.

The administrator's task is further complicated by the fact that how this uncertainty is perceived and how the associated risks are evaluated depend upon the stakeholders' varied perspectives. How people perceive risk depends on what they value, how the risk is framed, and their level of trust in the responsible organization or institution. Further, and perhaps even more important, every way of presenting risk information is a "frame" that can shape participants' judgments in a risk decision. This framing, too, is not an issue that can be resolved with better science. There is no scientific way to determine that one risk summary is more accurate or less biased than another when both accurately reflect the data. Consequently, the problem of generating a single unbiased summary of risk information to meet participants' needs in a risk decision has no purely technical solution.

The best resolutions to these twin dilemmas focus on the decision processes employed. To be effective, such processes must tightly integrate analysis and broader deliberation,

and should allow all participants to understand where scientists agree, where they disagree, and where their relative certainty ends (Stern and Fineberg 1996).

Managing national forests is a **wicked problem**.

Many of society's pressing problems in environmental management and elsewhere are characterized by high levels of complexity and social conflict. In such cases, profound social and cultural values come into play. In these most complex cases, the processes of defining shared values, common goals, desirable outcomes, and acceptable risks become political. Consequently, technical analyses alone—which do not integrate social values and deliberation—cannot provide an adequate decision-making support framework. In other words, when scientific uncertainty coexists with value uncertainty and conflict, we have "wicked" problems. It is important to note that the inherent characteristics of a wicked problem create a significant predicament for the decision maker: there is no right answer; the decision maker must act in the face of uncertainty and lack of consensus; and the decision maker will be held accountable for making the "right" decision, *as separately defined by each stakeholder*. The difficulty in coping with wicked problems increases as the issues' time and geographic scales increase. Many recent large-scale natural resource planning efforts, such as the Northwest Forest Plan and the Interior Columbia Basin, illustrate the difficulties in addressing wicked problems.

Our review of the administrative, ecological, and social context of the decision problem in the Sierra Nevada National Forests shows that

- the USDA Forest Service's dispersed management power,
- the often conflicting federal laws regulating and guiding management activities in the national forests,
- the Sierra Nevada National Forests' diverse biological environment, and
- the complex social and political environment in which decisions must be made

meet the definition of a wicked problem. Attempts by the USDA Forest Service Pacific Southwest Region to resolve issues involving protecting threatened species associated with old-growth forests in the Sierra Nevada began in 1992. The Region has diligently used state-of-art participatory techniques, the precautionary principle, and adaptive management to deal with the ecosystem's broad geographic scale, profound differences in stakeholder values, long planning horizon, and high scientific uncertainty. Yet the decisions continue to be subject to appeals and potential litigation as diverse stakeholders attempt to obtain outcomes favorable to their own senses of the "right" solution. However, as solutions to wicked problems are not "right or wrong," but only "better or worse," continued stakeholder dissatisfaction can only be understood through examining the decision-making processes.

We examined the most commonly proposed approaches for managing national forests, which naturally vary in their practical utility for guiding day-to-day decision making.

The **precautionary principle**, despite positive contributions related to safety-first considerations, does not provide useful, practical guidance to environmental managers, largely because taking no action is itself a course of action with environmental

consequences. "Safe minimum standards" and "critical natural capital" approaches are variations of the precautionary principle, and suffer from similar limitations when used in response to large-scale, complex environmental dilemmas. In addition, while focusing on "best management practices" (BMPs) can be seen as fitting well within the logic of adaptive management (an important component of environmental management), BMPs are neither robust enough nor flexible enough to serve as the primary tool for addressing wicked problems.

Adaptive management is a pragmatic approach to "learning by doing" involving cycles of policy implementation, experimentation, monitoring, feedback, and revised implementation. The concept originally was designed to deal with scientific uncertainty, but has been recently expanded to address social and political uncertainties through developing "learning networks." According to Lee (1993), if managers agree on both consequences and values, decisions can be based on an established routine of gathering and evaluating information. If there is agreement about management actions' effects, but disagreement about goals, a process of negotiation among the stakeholders is needed to develop acceptable policy. If management goals are broadly accepted, but there is disagreement or uncertainty about the impacts, adaptive management can be a useful tool for addressing and resolving these disagreements.

Adaptive management allows managers to agree on policy when they cannot agree on predicted outcomes; in this context, adaptive management is not a process for coping with disagreement over management goals and objectives (Johnson and Williams 1999). Obviously, any decision-making process will be limited in its effectiveness if there is ambiguity about the process's goals or objectives. Further, adaptive management cannot be applied when the risks of failure are socially and legally unacceptable, or where the ecosystems involved are not resilient to disturbance. Therefore, while adaptive management is necessary for dealing with wicked problems, it is not sufficient.

The concept of adaptive management has matured since its initial application to natural resources. What was *adaptive ecological management and assessment*, a science-driven process with some stakeholder involvement (Holling 1978), has become *adaptive collaborative management*, a facilitated stakeholder-driven process with scientist involvement to achieve stakeholder networks that learn and adapt together (Buck, Geisler et al. 2001).

While few examples of completely successful adaptive management experiences are available, a number of important concepts and recommendations have emerged from examining several case studies in depth.

1. Whenever possible, all stakeholders—including the public; interested federal, state and local agencies; and decision makers in the responsible organization's chain of command—should be invested in the process.
2. There must be an agency commitment to engaging external stakeholders and to adaptive management processes, including adequate funding for both monitoring and experimenting.

3. There must be an agency cultural shift from seeking optimal solutions to achieving negotiated progress towards preferred outcomes and stakeholder tolerance for reasonable risk taking.
4. While the precautionary principle is likely to guide short-term decision making in cases of high uncertainty, provisions must be made to allow for experimenting.
5. The entire decision-making process must be open and transparent.
6. The presence of endangered species requires actively engaging the responsible regulatory agencies, such as the U.S. Fish and Wildlife Service.
7. Using small and/or local-level experiments selected to respond to stakeholder risk and uncertainty preferences should be explored. Such experiments help build learning networks, build trust, provide short-term results critical to maintaining stakeholder interest, solve problems important to the stakeholders, provide lower risks to ecological communities and endangered species, and are easier and less costly to implement.
8. The process must be iterative, and incorporate and respond to stakeholder values.

As Bormann, Cunningham et al. (1994) explain,

> Because societal values and ecological capacity must be integrated to achieve sustainability, iterative interaction is required. Defining what is ecologically possible is not efficiently pursued without first knowing what people want; reconciling what is desired with what can be sustained and finding creative solutions require understanding what is and is not thought to be possible. Thinking about new possibilities does not come easily, and ideas from a broad cross-section of society are needed. (Bormann, Cunningham et al. 1994, p. 8)

Forest Service efforts to **involve the public**—particularly in their Pacific Southwest Region—have been laudable and will continue to be necessary, but our research shows current methods are not sufficient to resolve the challenge of gaining and maintaining public support. Both the National Environmental Policy Act (NEPA) and the National Forest Management Act (NFMA) mandate public participation, but provide little guidance as to how that participation is to occur, and what role the public has in the ultimate decision. Historically, "public participation" has been interpreted to mean providing opportunities for the public to comment on proposed federal actions that may impact the environment. In the Sierra Nevada Forest Plan case, the Forest Service has gone far beyond this minimal level of public participation; in fact, at the time this level of public participation was unprecedented in federal land management planning. Nonetheless, recent Forest Service decisions in the Sierra Nevada have met with a large number of appeals, attempts to intervene, and other indications that there may not be strong public support for the decisions made. Despite the Forest Service's best efforts, public participation to date has failed to achieve the desired outcome of substantial public support for their Sierra Nevada National Forests decisions.

Recognizing that managing the Sierra Nevada National Forests is a wicked problem is important in appropriately characterizing the challenges facing the Forest Service in the future. One immediate implication is acknowledging that, as a wicked problem, *there will be no optimal solution*. No amount of scientific or analytical effort will produce a

solution that addresses, with sufficient certainty, all the critical ecological and political aspects of the management problem for all stakeholders. Instead, the most productive approach for dealing with wicked problems will be to *seek broadly satisfactory, rather than optimal, solutions*. A "satisfactory solution" in this context implies one that is consistent with ecological and legal constraints and is also acceptable to the public. We characterize this approach as "collective satisficing"

Since there is no optimal solution to the Sierra Nevada National Forests management problem, the greatest short-term risks for the Forest Service are related to decision processes rather than ecological outcomes. The Sierra Nevada Forest Plan Amendment process is a wicked problem characterized at all levels by multiple risks and uncertainties. Both the scholarly literature and best practice from a number of environmental management arenas indicate that the most effective approach for dealing with such decisions is to develop a decision process that tightly integrates the best scientific analysis and the fullest possible public participation and deliberation. Management decisions at the scale of the Sierra Nevada, however, require developing new approaches to participation that go beyond available methods, which tend to be tailored to small–scale and/or localized participation.

The participatory approach we suggest, a "learning network," incorporates the key aspects of the Forest Service's NEPA and forest-planning processes. Our 10-step Learning Network (Figure 14 in Chapter 7) provides for a more explicit modeling of stakeholder preferences and uses these preferences in developing and assessing initial alternatives. Modeling preferences would allow the Forest Service to assess the values and preferences of a broad cross-section of stakeholders. Linking those preferences explicitly to the science models used to generate alternatives will likely sample a much broader range of alternatives—which will increase the likelihood of identifying alternatives which offer the greatest promise of being broadly acceptable.

The challenge of linking the best science with active and innovative assessment methods, and addressing public priorities in an ongoing adaptive management system, is daunting, and will certainly require periodically reassessing the Forest Service's institutional structure and continued commitment to integrating public participation into decision-making processes. It will be neither easy nor cheap. Yet it will be essential for successfully managing the Sierra Nevada National Forests.

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